Acute Care Enhanced Surveillance

ACES User Manual

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1 ACES BACKGROUNDER

Acute Care Enhanced Surveillance (ACES) provides real-time epidemiological surveillance for Ontario. ACES monitors triage (emergency visits) and inpatient (admissions to hospital) records from over 70% of Ontario's acute care hospitals. Records are monitored as the patients are being treated, giving real-time situational awareness for disease outbreak and other potential health risks. Hospital visits are monitored with a sliding scale of specificity, from a province-wide assessment to our smallest level of geography, the FSA (forward sortation area, the first three characters of Canadian postal codes). The temporal and spatial capabilities built into ACES enable public health to be better informed on the health of the community which, in turn, can improve public health protection and prevention initiatives.

This manual has been prepared to familiarize you with ACES in the following ways: (1) as an introduction to ACES' capabilities; (2) to provide you with practical assistance in using ACES; and (3) to provide you with a detailed scientific background for the theory and technology used in ACES. You can begin reading Section 1 for an overview of ACES' applications and future directions. In Section 2, a guide to the ACES interface is provided, including a description of all functionalities, such as mapping and alerting protocols. The scientific background found in Section 3 chronicles the development of ACES, important scientific concepts, and technical terminology.

1.1 Introduction to ACES

The global nature and faster pace of the contemporary health care environment have presented formidable challenges to traditional methods of health surveillance. These traditional methods, including surveys, regular reporting of priority diseases from sentinel primary care practices, and retrospective analysis of hospital charts, were put to the test in the fall of 2003 with the pandemic threat of SARS. Numerous reports from this period, including the Walker Report, the Naylor Report, and the Campbell Commission, confirmed that Ontario's emergency preparedness was in need of updating, in addition to the need for better health surveillance. Concurrent to global events that were testing the

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limits of public health surveillance, developments in machine learning were making large-scale automated data analyses possible, and advances in geographic information systems (GIS) were enabling geospatial visualizations of data at global, national, and regional scales. At this confluence of public health need and technological advancement was the development of real-time surveillance methods capable of providing essential monitoring for a growing list of health conditions, such as influenza outbreaks, the effects of climate change and extreme weather events, specific causes for injury and asthma, and clusters of health effects related to illicit drug use.

ACES was started as a two-year pilot project called the Emergency Department Syndromic Surveillance (EDSS) system with just two Kingston emergency departments in 2004. The Emergency Department Syndromic Surveillance system was both developed and funded by a collaboration between Kingston, Frontenac, and Lennox & Addington (KFL&A) Public Health, the Public Health Division of the Ministry of Health and Long-Term Care (MOHLTC), Queen's University, the Public Health Agency of Canada (PHAC), Kingston General Hospital (KGH) and Hotel Dieu Hospital (HDH). EDSS was based on an open-source software package from the University of Pittsburgh's Real-time Outbreak and Disease Surveillance (RODS) system. The RODS system was modified for the needs of an Ontario-based population, such as the customized geospatial mapping and the optimization of alerts and syndrome classification. The EDSS system collated specific data elements from triage records such as chief complaint (as free text), date and time of visit, hospital name, patient age, patient sex, and patient postal code (to 5 characters). Classifying algorithms derived from machine learning applications were used to categorize each emergency department visit into pre-defined and medically significant syndromes according to the words, parts of words, and phrases found in the chief complaints. Eight syndromes were defined for the EDSS system, including, for example, *gastrointestinal* (to capture all potentially infectious gastrointestinal conditions) and *fever/influenza-like-illness (ILI)* (to capture all potentially infectious ILI conditions). Since its inception in 2004, ACES has grown from its original two emergency departments at KGH and HDH, to more than 115 acute care hospitals in 28 health units across Ontario, with the long-term goal of including all acute care facilities in Ontario.

In early 2015, the EDSS was renamed Acute Care Enhanced Surveillance (ACES), to reflect the broadening of the scope of the acute care partners participating in the system across Ontario, as well as the system's enhanced capabilities. The system continues to be maintained by KFL&A Public Health with funding from the MOHLTC. From the more than 115 acute care hospitals contributing triage and admission records to ACES, approximately 12,000 visits and 3,000 hospital admissions are logged per

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day. ACES, like the EDSS, continues to allow users to (1) monitor acute care hospital volume, admissions, and surge capacity to help prepare for high volumes of patients, particularly in the event of an influenza pandemic, (2) monitor trends and/or changes in the incidence of endemic disease, and (3) detect new or emerging public health threats. The additional acute care coverage of ACES allows for unprecedented situational awareness both within specific public health jurisdictions and across Ontario. The enhanced capabilities of ACES include improved and more interactive epidemiological assessment tools, such as more intuitive graphing, built-in calculations of standard deviations and moving averages, and monitoring capabilities that have been updated to reflect real-time values instead of arbitrarily fixed intervals. Furthermore, ACES gives you access to report visit and/or admission volumes based on either (a) hospital location or (b) patient address. Like EDSS, ACES continues to provide real-time health surveillance, but with a wider reach to more Ontarians, and with a greater capacity for extracting meaningful information for public health.

1.2 ACES Applications

The flexibility, adaptability, monitoring and analysis capabilities of ACES enable situational awareness for a variety of common, emerging, or unexpected public health issues. ACES' syndromic surveillance capabilities are useful in a variety of situations, including:

- ✓ *routine monitoring of seasonal influenza;*
- ✓ *reportable disease detection;*
- ✓ *public health emergencies;*
- ✓ *surveillance of mass gatherings;*
- ✓ *public health emergencies (such as fires and extreme weather events);*
- ✓ *monitoring of asthma;*
- ✓ *surveillance after drug policy; and,*
- ✓ *mental health surveillance.*

1.2.1 Influenza

ACES provides invaluable information for health care services throughout Ontario for seasonal influenza. Most notably, the ILI Mapper was developed from ACES, a feature that displays provincial respiratory and influenza activity in both map and graph forms to assist public health professionals to track influenza activity and various other respiratory illnesses throughout the annual influenza season. The

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interactive and freely accessible on-line ILI Mapper detects, monitors and describes the annual influenza outbreak in your region. Information about surge capacity, virus progression and infection rate enables public health agencies and health care services to plan and implement alternative strategies for protecting the public during influenza season. Furthermore, the ILI Mapper is publically available so that all Ontarians can access real-time information regarding the overall influenza status of the province, as well as the trends observed at increasingly specific levels of geography. This increases the awareness of influenza risk and enables individuals to be better informed to protect themselves from transmission of the virus.

The value of ACES for monitoring potential influenza pandemics was shown during the H1N1 epidemic in 2009. Although influenza viruses circulate each year, the H1N1 pandemic was of particular concern as it had a higher than normal infection rate, and it did not infect older adults at disproportionate rates as is normally expected. In other words, H1N1 was infecting otherwise healthy and young people at alarming rates. The first cases of H1N1 in Ontario were confirmed in late April 2009. When a second wave of the H1N1 outbreak occurred in the fall of 2009, ACES (then called EDSS) was used to monitor the outbreak in real-time within the KFL&A region. Analyses of ACES' *respiratory* and *fever/ILI* syndromes were able to detect and describe the increase in emergency department visits for respiratory complaints leading up to and during the H1N1 outbreak. Surveillance maps generated using ACES were able to visually identify regions with high numbers of ILI-related emergency department visits. Additionally, the momentum demonstrated in the ACES-generated epicurves indicated that there would likely be continuously increasing numbers of patients visiting KFL&A's emergency departments, threatening an overload of each emergency department's capacity. Based on this information, assessment centres were established to relieve the pressure on the emergency departments, resulting in a decline in emergency department visits over the next two weeks. The use of ACES throughout the H1N1 pandemic demonstrated its multiple capabilities in assisting with a disease outbreak: not only was the system able to help detect, describe, and track the outbreak earlier, but it also helped to warn health professionals of increased patient number to enable a concerted health system response.

1.2.2 Reportable disease detection

Through the Health Protection and Promotion Act (HPPA), public health agencies in Ontario are required to track over 50 communicable diseases (Appendix D). Notification of a case of these diseases usually occurs through the testing laboratory, and public health is required to notify patients of the treatment options, as well as what to expect during the course of their illness and/or treatment. Reportable

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diseases can be monitored using ACES in several different ways. Specific syndromes related to the reportable disease can be monitored; key words from the chief complaints specific to the disease are used to classify potential cases. Alternately, epidemiologists can examine individual ED records in ACES and flag instances that require further investigation by a public health nurse, infection control practitioner or health inspector. In the near future, this process will be automated and become an even more timely service that includes direct emailing of line list data to the appropriate person to allow for even quicker follow-up than may occur via current lines of communication. This will allow public health agencies to meet their obligations through the HPPA while also allowing for the quick isolation (if necessary) and education of the afflicted patient to mitigate the potential spread of the disease.

1.2.3 Mass Gatherings

1.2.3.1 G8/G20 Summit

Mass gathering events have the potential to generate significant public health risks. Appropriate public health preparations are required before the event, as well as sufficient surveillance during the event, to attenuate potential health emergencies. From June 25th to 30th, 2010, the G8 and G20 Summits were held in Huntsville, ON and Toronto, ON, respectively. A Hazard Identification Risk Assessment (HIRA) was completed in preparation for the event due to the large crowds expected to attend the events. The HIRA identified several potential risks including: infectious and contagious diseases, food related hazards, environmental/severe weather emergencies, and injury/health and safety hazards.

The ACES system was used as a surveillance tool during the G8 and G20 Summits to monitor syndromes that coincided with the identified risks. From June 17th to June 30th the system monitored specific health syndromes every hour, looking for increases in hospital ED visits and admissions that may indicate an emerging public health threats related to the event. Throughout the monitoring timeframe, three indicators on the system were higher than expected values: (1) total hospital admissions, (2) *fever/ILI* emergency department visits, and (3) *dermatological infectious* emergency department visits. It was noted, however, that these values were not significant or sustained. The use of ACES during the G8 and G20 Summits allowed for real-time monitoring of identified public health risks, enabling situational awareness of potential emerging issues and enhancing health system preparedness.

1.2.3.2 2015 Pan/Parapan American Games

In the summer of 2015, Ontario's Greater Golden Horseshoe area will be hosting the Pan/ParaPan American Games. The event will include an estimated 10,000 athletes and 250,000 visitors. In preparation for the Games, a provincial Surveillance Work Group was created, and several surveillance objectives were outlined, including the recommendation that ACES be used throughout the event for public health surveillance. With over 100 hospitals in twenty-six health units participating in the system across Ontario, ACES extends through all regions that may be affected by the Games, and includes nearly all of the hospitals within close proximity to event locations. Due to its flexibility, adaptability, and its strong monitoring and analysis capabilities, ACES will be extensively used by stakeholders during this time.

1.2.4 Emergencies and Extreme Weather

1.2.4.1 Kingston Fire

On December 17th2013, a large fire broke out in a construction site near downtown Kingston, ON. The size of the fire and the wind conditions at the time led to concerns regarding the spread of fire to nearby buildings, as well as the potential production of a substantial amount of smoke. The fire, therefore, posed a significant threat local air quality, in addition to the health risks associated with exposure to fire, smoke, and carbon monoxide. Upon being notified of the fire, KFL&A Public Health began monitoring ED visits and admissions to local hospitals that could be related to the event using ACES. Specifically, emergency department visits related to respiratory ailments and asthma were monitored for aberrations in normal/expected volumes. In particular, ACES was used to monitor for increases in emergency department visits for smoke inhalation and carbon monoxide exposure. Though no significant increases were detected, the ACES system was able to help quickly assess the extent of the public health threat and inform hospitals of the potential degree of expected patient volume influx. ACES improved the overall situational awareness and preparation throughout the duration of the emergency. In addition to ACES, the Public Health Information Management System (PHIMS) was used for enhanced situational awareness during the fire; PHIMS enables the assessment of wind patterns and air quality. Using ACES and PHIMS, public health was able to determine the geographic locations in Kingston that were at the highest risk for exposure to the effects of the fire, including determining the most vulnerable individuals in this area who should be given special consideration during evacuation efforts.

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1.2.4.2 Midland Tornado

In times of unexpected disaster, the ACES can assist first responders and emergency operations personnel. On June 23rd 2010, a F2 Tornado hit Midland, ON. Winds in the area reached between 180 and 240 kilometres an hour as the tornado cut a strip through the centre of the town, causing severe damage and leading the town to declare a state of emergency. In the minutes after the tornado struck, ACES was employed to show, in real-time, the ED registrations related to the tornado at the local hospital. ACES was used to monitor visits for trauma in order to assess the extent of the injuries caused by the tornado, as well as monitor the potential emergency department surge relative to local emergency department capacity, and led to enhanced situational awareness during this emergency.

1.2.5 Surveillance After Drug Policy Changes

1.2.5.1 Methadose

Methadone is a synthetic opioid used in the maintenance treatment of patients who are addicted to opioids, such as heroin and morphine. On June 26th 2014, the delivery of methadone maintenance therapy was changed in Ontario: the program began a transition from prescribing a compounded methadone solution to a more concentrated formulation of an oral solution of Methadose, leading to potential dosing errors and accidental overdose. On July 17, 2014, KFL&A Public Health initiated a surveillance program using ACES to assess recent ED visits for methadone overdose or accidental opiate overdose. An increase in emergency department admissions may indicate a negative effect of the new program. The pre-existing syndrome used to capture opiate-related emergency department visits was modified to monitor methadone-specific emergency department visits and admissions. Public health professionals were able to conclude that methadone overdose numbers were stable over the weeks before and after the initiation of the new program. ACES provides on-going monitoring of methadone-related emergency department visits.

1.2.5.2 Delisting of OxyContin

OxyContin is an opioid analgesic that is prescribed to treat moderate to severe pain; it is safe when used as prescribed, but its misuse can lead to addiction or overdose. OxyContin was removed from the list of drugs funded by the province of Ontario in March 2012 and OxyNEO, considered more difficult to abuse, is being prescribed instead. Controls on prescribing OxyNEO also became stricter around this same time. These changes were intended to try to reduce the harms and deaths associated OxyContin abuse. To

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help determine whether these policy changes had any impact on population health, ACES was used to monitor changes in the visit and admission patterns regarding narcotics abuse. Weekly reports were generated to provide evidence regarding the effectiveness of the new OxyContin policy, and to identify any potential unintended consequences. Analysis of ACES data is ongoing, but initial results indicate that narcotic related visits and admissions remain stable from values before the new policy's inception.

1.2.6 Asthma

Approximately 13% of Canadian children aged 0 to 14 years have asthma, and it is the leading cause of hospitalization for children and a significant cause of absenteeism from school and the workplace. Asthma also presents a significant financial burden on the health care system (see the MOHLTC's *Taking Action on Asthma*). Each year, shortly after children return to school in September, there is a recurring increase in ED visits, hospital admissions, and unscheduled physician consultations for childhood asthma across North America. Rhinovirus infections, allergens, and decreased use of asthma medications during the summer are all thought to be contributors to this problem. ACES is used to monitor asthma related emergency department visits by children in the KFL&A region as they return to school each fall, and, as expected, a significant rise in emergency department visits is observed each year. Analysis of this information enables health professionals to assess the annual epidemic and understand the extent of the issue, as well as assist the preparation of prevention efforts to reduce the impact of the problem by determining the local regions with the highest rates of asthma, and therefore, in greatest need of intervention strategies.

1.3 Future Directions

The expansion and upgrades made to ACES have gone a long way to improve public health awareness across the province and its wide acceptance inspires our team to maximize the potential of ACES. In addition to the applications mentioned in the sections above, we are expanding the scope of ACES to include mental health surveillance as well as the integration of several new syndrome-specific mapping tools. These non-traditional approaches to syndromic surveillance will allow health care agencies to plan strategies to cope with predictable increases in emergency department volume, as well as identifying possible patterns related to demographics, location, or timing of the cases that would justify further investigation or intervention.

Progress is being made to create syndromes for both emergency department visits and inpatient admissions for mental health matters such as suicidal ideations, alcohol intoxication/addictions, sleep

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disorders, and opioid intoxication/addictions. ACES' ability to monitor mental health syndromes will help fill a gap in Ontario's surveillance capabilities as there is currently no real-time surveillance system for mental health issues. The real-time monitoring of mental health related visits and admissions will enable the immediate provision of information to health organizations and providers on the volume of patients using emergency departments for mental health issues. It will also help to identify emerging substance abuse issues and improve situational awareness around mental health issues after major events and during mass gatherings. This information could help improve the understanding of local mental health needs, improve service delivery, and provide evidence for relevant policy changes. The flexibility of the ACES system will enable efficient expansion for a range of mental health indicators, allowing for surveillance and improved public health responses to these important health issues.

As mentioned previously, ACES is currently being leveraged via the ILI Mapper to help local and provincial stakeholders (along with the public) be better informed on the progression of the annual influenza season. There are currently plans to develop similar applications with other ACES syndromes, including (1) an Asthma Mapper to detect (both spatially and temporally) the annual rise of asthma-related emergency department visits for children as they return to school from the summer break, (2) a GI Mapper to track gastrointestinal related visits to hospitals throughout the year for the early detection of potential food related outbreaks, and (3) a Respiratory Syncytial Virus (RSV) Mapper to detect specific respiratory complaints, such as bronchiolitis in children under the age of 5, to ensure they are differentiated from the overall respiratory data for focussed interventions. Mappers for any disease or condition could potentially be created, with appropriate statistical validation, stakeholder interest and potential benefit.

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2 USER INTERFACE GUIDE

2.1 Data Collection and System Overview

In Section 2, the normal usage of ACES is described, providing guidance for the new user, and instructions on accessing the enhanced surveillance features for advanced users. Each section describes how to use ACES, ranging from logging in to making full use of ACES' alerting capabilities. Links are provided when applicable to more detailed background information in Section 3.

2.1.1 Data Collection

All data for ACES is collected by participating health care facilities during the registration and triage process. When a patient presents at the emergency department, details describing both the patient and the visit are entered into the hospital's computer system as a patient is registered, or within minutes. Without any additional action on the part of the hospital staff, ACES captures select information from triage records and, therefore, has no measureable impact on the hospital staff's workload. Data elements collected by the ACES system include patient demographics (e.g., age, sex, first five characters of residential postal code), the date and time of the visit, chief complaint(s), Canadian Triage Acuity Score (CTAS), febrile respiratory illness (FRI) screening results, admission diagnosis (if recorded and available), discharge diagnosis (if available), mode of arrival (e.g., ambulance), and admission to intensive car, if applicable. To ensure identity protection and privacy requirements, no direct personal identifiers (e.g., name or health insurance number) are collected by ACES, and the data is sent from hospitals to KFL&A Public Health's data centre over the secure Ontario e-Health network**.** The data collection process is shown in Figure 1.

2.1.2 Data Processing

All data collected from each participating emergency department is stored at KFL&A Public Health's secure data centre. Each visit from our acute care partners are classified into one of ACES pre-defined syndromes (medically-significant categories based on the chief complaint or admission diagnosis; see APPENDIX C - ACES Syndromes). The classification process uses algorithms derived from natural language processing (NLP). The various phrases, words or parts of words found in the chief complaint are used to classify each visit into the syndrome it most likely belongs. At this stage, anomaly detection

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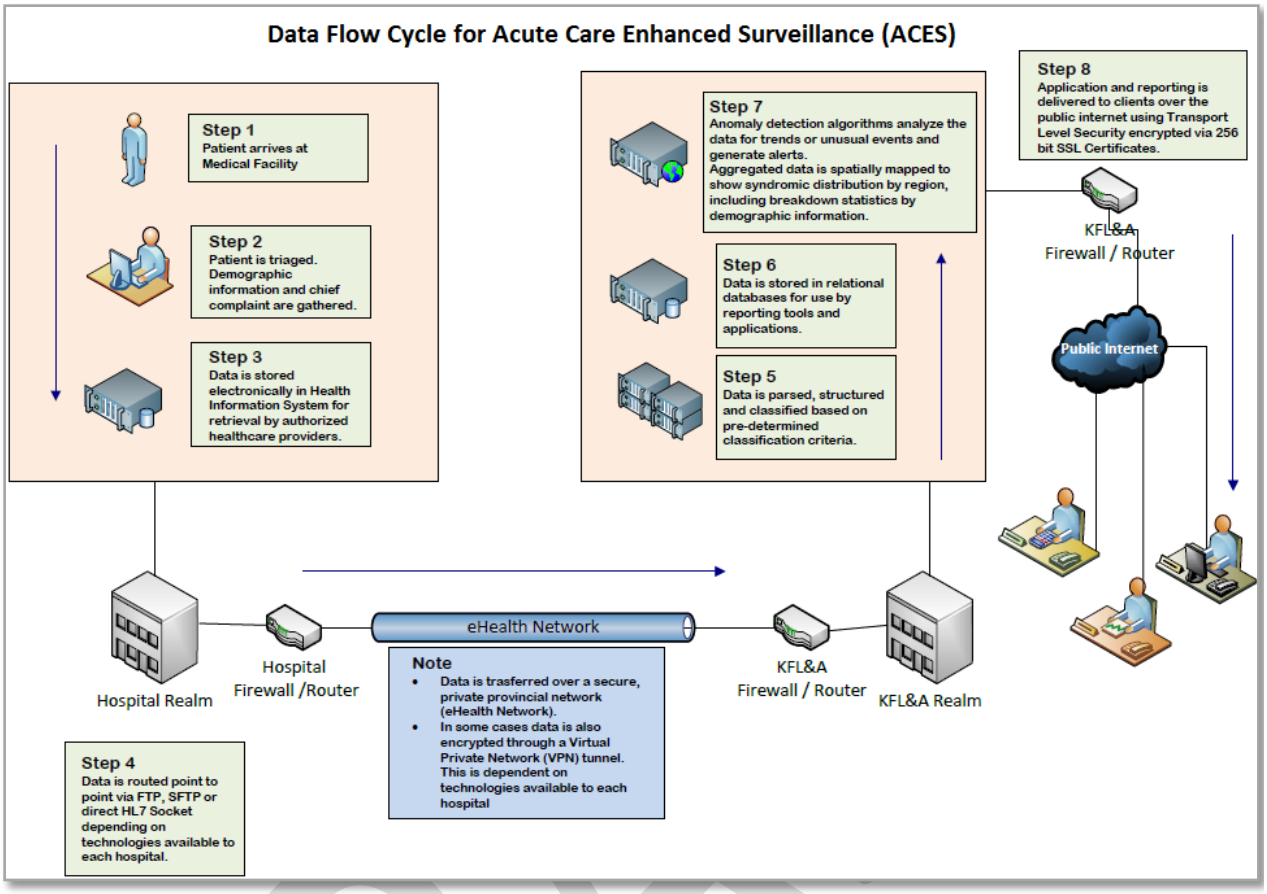
Data Flow Cycle for Acute Care Enhanced Surveillance (ACES)
Step 1
Patient arrives at Medical Facility
Step 2
Patient is triaged. Demographic information and chief complaint are gathered.
Step 3
Data is stored electronically in Health Information System for retrieval by authorized healthcare providers.
Step 4
Data is routed point to point via FTP, SFTP or direct HL7 Socket depending on technologies available to each hospital.
Step 5
Data is parsed, structured and classified based on pre-determined classification criteria.
Step 6
Data is stored in relational databases for use by reporting tools and applications.
Step 7
Anomaly detection algorithms analyze the data for trends or unusual events and generate alerts.
Aggregated data is spatially mapped to show syndromic distribution by region, including breakdown statistics by demographic information.
Step 8
Application and reporting is delivered to clients over the public internet using Transport Level Security encrypted via 256 bit SSL Certificates.
KFL&A Firewall / Router
Public Internet
Hospital Realm
Hospital Firewall /Router
eHealth Network
KFL&A Firewall / Router
KFL&A Realm
Note
Data is trasferred over a secure, private provincial network (eHealth Network).
In some cases data is also encrypted through a Virtual Private Network (VPN) tunnel. This is dependent on technologies available to each hospital

Figure 1. ACES data collection and flow cycles.

methods are used to discern any potential trends or daily visit increases that may be statistically distinctive suggesting (at worst) an outbreak (see Section 3.6 Alerts and Outbreaks).

In the event that an abnormal number of visits for a syndrome are detected, alerts generated by the ACES system are immediately posted to the website (http://aces.kflaphi.ca/#/). Epidemiologists and other health professionals can then use the secure web-based interface to monitor the collated information, and assess the emergency department visits that caused the alert. They can determine if there are any patterns related to demographics, location, or timing of the cases that would justify further investigation by public health staff. The data is collected in real-time and is based on disease symptoms, rather than diagnosis; therefore, ACES improves opportunities for both early detection and response to public health threats.

2.1.3 Data Security and Privacy

Although all data collected for ACES from participating hospitals are stripped of key identifiers (i.e., name, health card number, residential address, full postal code), the data are nonetheless treated as personal health information under the Personal Health Information Protection Act (PHIPA), and steps are taken to protect the security and confidentiality of all information. The ACES Privacy and Confidentiality Charter outlines the policies, principles, and procedures for ACES that are necessary to meet the intent of PHIPA. A Privacy Impact Assessment has been conducted for ACES, and there are regular reviews of the ACES policies and procedures to ensure they are in alignment with PHIPA and any other applicable privacy legislation. KFL&A Public Health enters data sharing agreements with all of its health unit and hospital partners on ACES. All of these policies and procedures ensure that all health information extracted, stored and processed using ACES is protected.

2.2 Login Page

Registered users can access ACES at http://aces.kflaphi.ca/#/ . Logging in requires both username and password. Users will be given access to the data according to their data sharing agreements. For more information, contact the ACES team at kflaphi@kflapublichealth.ca.

2.3 Main Landing Page

Upon logging in, you will be directed to ACES' main page. This page provides an overview of recent, provincial emergency department activity, as well as current alerts. On the top half of the page, there are a series of six charts that display (1) all acute care hospital visits across Ontario for the past sixty days, as well as visit counts for five syndromes of common public health interest, that is (2) respiratory, (3) gastrointestinal, (4) environmental (ENVIRO), (5) influenza-like illness (ILI), and (6) Asthma (Figure 2). These graphs are not interactive and permit the user a quick overview of the whole province for situational awareness regarding acute care use in general, and the relative activity for the five syndromes shown. The bottom half of the page displays a table with a list of current alerts (Figure 3). For an explanation of the different alerts in ACES, see Section 3.4.

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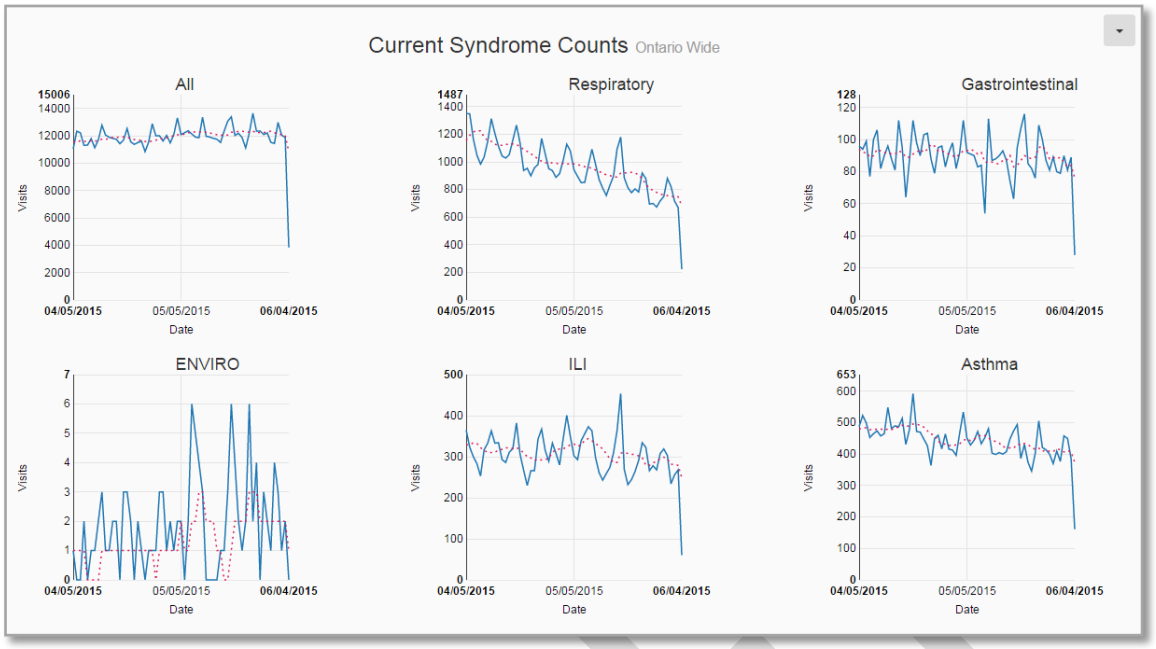

Figure 2. Main landing page - current syndrome counts for Ontario. Note: count for current day reflect the time of day.

NEW SCREEN SHOT OF THE CURRENT ALERTS

Figure 3. Main landing page - current alerts.

You can customize the information display using the gray arrow on the upper right corner of the alerts table. Choices for display include alert date/time, alert class, alert type, syndrome, geography type, geography name. Click on the box before the data element to display or turn off the information, or click on the **Group By Icon** after the data element to display the information grouped by that parameter

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NEW SCREENSHOT FOR DROP DOWN MENU WITH GROUP BY OPTIONS

Figure 4. Dropdown display for current alerts.

(Figure 4). ACES' default setting is to display all of these parameters by date/time. Clicking on the gray arrow again will collapse the options display.

The next sections will describe the different menu tabs that enable you to utilize ACES to suit your agency's needs and goals. The main navigation options are shown as tabs in the top right corner of the ACES main page (Figure 5). Each tab will be discussed in sequence: Epicurves, Line Listings - ED, Line Listings - AD, Maps and Alerts.

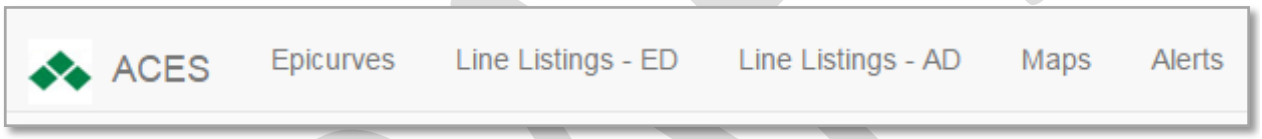

Figure 5. Main navigation options.

2.4 Epicurves

The Epicurves page allows you to graph acute care facility visits as a function of various user-defined parameters, such as geographic region, gender, age and date. The default display is a chart of all visits for the past seven days, for all hospitals, gender and ages (Figure 6). At the top of the chart are options to add statistically descriptive features to the graph (Figure 7): **None** (no moving average displayed) is the default setting, **7** (seven day moving average is displayed as a dotted line), **14** (fourteen day moving average is displayed) and **Max** (the overall mean for the chosen time period is displayed). Moving average is calculated as the mean of the last seven (or fourteen) days including the

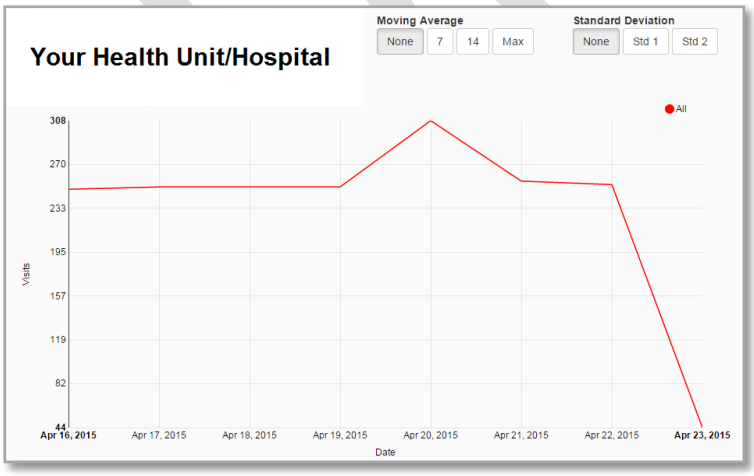

Figure 6. Default epicurve display.

current day, and is often used in time-series data to smooth out short-term fluctuations. When considered in concert with the standard deviation (also calculated from the same seven or fourteen day period), the moving average provides a simple smoothing technique for your data. You can choose to display **None**, one standard deviation (**Std 1**), or two standard deviations (**Std 2**).

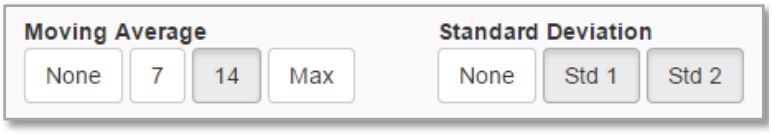

Figure 7. Data display options.

2.4.1 Epicurve Display Options - Tools

There are many options available to customize and optimize the epicurve. Be sure to carefully choose from the options available for each parameter as there are many options available to optimize data display and retrieval. The **Tools** menu, shown in Figure 8, has various options for sorting data:

- ☑ **Health Unit** (choices available here are dependent upon your administrative credentials);
- ☑ **Hospital** (choose from the dropdown list; the default setting is **All**),
- ☑ **Date Range** (enter dates manually or click on date to choose from dropdown calendar, the default setting displays the previous week);
- ☑ **Gender** (the default is **All**);
- ☑ **Age** (choose from dropdown options, or fill in manually; the default is **All**);
- ☑ **Classifications** (see details below); and,
- ☑ **CTAS** score (the default is **All**).

NOTE: When all display options have been chosen, click the large green **Submit** button. **Reset** will return all parameters to default settings.

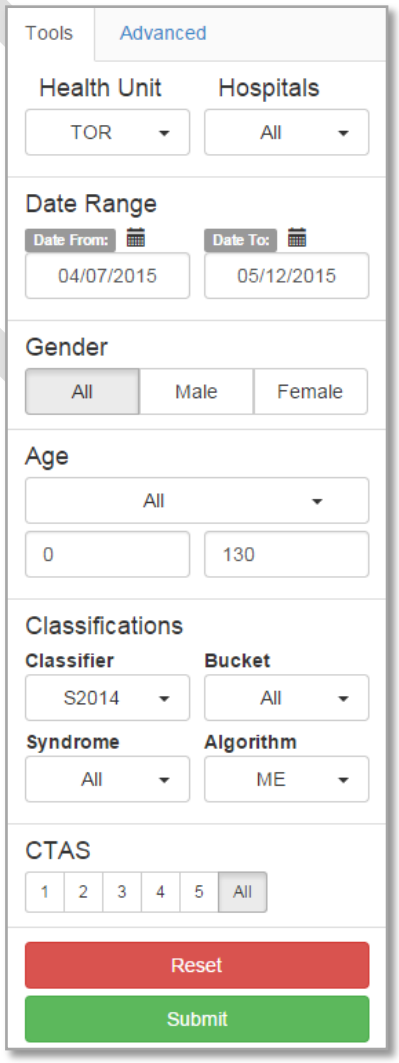

Figure 8: Epicurve display options - tools.

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2.4.1.1 Classifications

This category allows you to choose specific options regarding the syndromic classification you want displayed. Under **Classifier**, the dropdown menu gives the option to display either syndrome data that was classified according to the older EDSS/RODS classifier, **S2006** (**EDSS Standard Syndromes, v2006**), or by the new ACES classifier, **S2014** (**ACES Standard Syndromes, v2014**); the default is **S2014**. If **S2006** is selected, only the eight (with an additional category of **All**) syndromes that were associated with the EDSS system will be displayed. For a discussion of how hospital visits are classified into the various syndromes, see Section 3.3 Syndrome Classification using Natural Language Processing. The following syndromes are available as display options under the **Syndrome** dropdown menu: (1) **All,** (2) **Asthma**, (3) **Dermatological,** (4) **Fever/ILI,** (5) **Gastrointestinal**, (6) **Neurological**, (7) **Other**, (8) **Respiratory**, and (9) **Severe Infectious**.

Conversely, the default new classifier, **v2014**, you will notice that there are many more syndromes available for display, reflecting the number of syndromes currently being monitored. The syndromes are shown in the dropdown menu in alphabetical order, with **All** as the first option. The abbreviations and descriptions of **v2014** syndromes are given in APPENDIX C - ACES Syndromes. A discussion of their meaning and validation against diagnostic codes is found in Section 3.3.5 Syndrome Validation. In addition to the syndromes available using the **v2014**, the **Bucket** dropdown menu allows you to customize your epicurve using pre-defined groupings of certain syndromes of interest. For example, **ENVHE** (**Environmental Health Exposures**) displays the results from **Asthma**, **CHF** (congestive heart failure), **COPD** (chronic obstructive pulmonary disease), **DEHY** (dehydration), **ELECT** (electrolyte imbalance, hyperkalemia, hypomagnesium, hyponatremia), **ENVIRO** (heat stroke, heat syncope, heat exhaustion, cold-frost bite, hypothermia), and **MIGR** (migraine) syndromes. **Bucket** categories and their definitions are an on-going and dynamic project, and may potentially be customizable in future versions of ACES.

Finally, the **Algorithm** dropdown menu provides five options for choosing the classifying algorithm used to categorize the emergency department visits into the selected syndrome. The classifying algorithms used in ACES are mathematical models used to sort ED visits into syndromes by statistically categorizing the phrases, words and parts of words found in the chief complaints of the triage records. For example, if the word “fever” was the only word used in a chief complaint, the hospital visit would very likely be sorted into a syndrome for which fever is a common symptom, such as **ILI (fever, myalgia,**

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undifferentiated flu), and not very likely to be sorted into **DERM (rash, undifferentiated, lesion, wart)**. The algorithm options are **BW** (Balanced Winnow*),* **C4.5** (C4.5 Decision Tree)*,* **ME** (Maximum Entropy), **NB (**Naïve Bayes), and **W** (Winnow2). The default setting is **ME**. The option for changing the sorting algorithm is included in ACES to provide corroborative evidence for the sorting processes; for example, if you think an emergency department visit has been misclassified, it may be helpful to observe the results for different algorithms before seeking further technical advice. For further descriptions of the classifying algorithms used in ACES, see Section 3.3 Syndrome Classification using Natural Language Processing. NOTE: when all display options have been chosen, click the large green **Submit** button. **Reset** will return all parameters to default settings.

When a specific syndrome is displayed, you can choose from several different statistical display options. As described earlier for *All* visits, **7** or **14** day moving averages can be displayed, or **Max** to display the average for the displayed data range, as well as the corresponding standard deviation (**Std 1** or **Std 2**) (see Section 2.4 for more information). When you are displaying a specific syndrome, the option of **Normalize** is available, and the number of acute care visits for that syndrome will be displayed as the percentage of total visits (Figure 9). Additionally, several options appear below the statistical display options when you choose **Normalize**: click on the red or black circles to display the indicated statistical parameters on the epicurve.

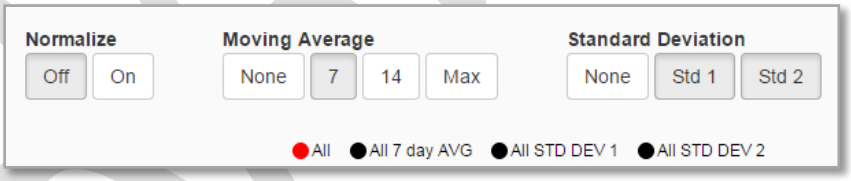

Figure 9. Normalize and other statistical options.

2.4.2 Epicurve Display Options - Advanced

Choosing the **Advanced** tab at the top of the options menu gives you more choices for optimizing the display of your data (Figure 10). The options include **Locality**, which determines the geography of either the patients or the hospitals displayed. It is important to note that you must choose **Local** for at least one of the options. Choosing **Local PHU Patients** from the **Patients** dropdown menu will display only patients with postal codes from the PHU's local region; **Province Wide** displays all Ontario patients; **Outside of PHU Patients** displays all patients from outside the PHU's region, as determined by postal code. Likewise,

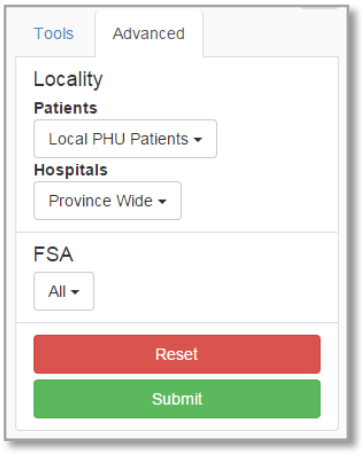

Figure 10. Epicurve display options - advanced.

patients from specific **Hospital** geography can be displayed: choose **Local PHU Hospitals** from the **Hospital** dropdown menu to display patients using the hospitals within the health units' jurisdiction; choose **Province Wide** and **Outside of PHU Hospitals** for all Ontario hospitals and just those outside of the local area, respectively. Keep in mind that only data from participating hospitals are included, and the extent of specific patient and hospital data to which you have access depends on your account credentials. Hospital users will only have the option to view their own hospital data, and health unit staff will be able to view all participating hospital(s) within their health unit. When all display options have been chosen, click the large green **Submit** button. **Reset** will return all parameters to default settings.

2.4.3 Creating an Epicurve - An Example

The following is an example of the steps needed to create an epicurve in ACES. After logging in, select the **Epicurves** tab at the top of the page (Figure 5). At the top of the graph, choose a moving average and standard deviation (optional). These options should now appear in the legend depending on your choices, and corresponding lines on the graph. Now turn your attention to the **Tools** menu and select the following:

- ☑ **Health Unit** = your health unit;
- ☑ **Hospitals** = **All**;
- ☑ **Data Range** = from today's date to three weeks previous to today;
- ☑ **Gender** = **All**;
- ☑ **Age** = **All**;
- ☑ **Classifications: Classifier** = **S2014, Bucket** = **All, Syndrome** = **All**, and **Algorithm** = **ME;**
- ☑ **CTAS** = **All**.

Remember to click on the green **Submit** button when all the options have been selected. The result of these choices is shown below for May 12, 2015 from KFL&A Public Health (Figure 11). Your display will be different, but should represent measurable visit counts as you have chosen all syndromes. If you like, choose a specific syndrome or change the dates of the data range. Remember to press **Submit** after making any changes. To return to default display settings, click **Reset**. In the chart, the **red solid** line displays the visit counts over the specified time period. The dotted line displays the seven day moving average, the dashed line is one standard deviation above the moving average, and the dash + dotted line displays two standard deviations above the moving average**.** You do not need to press **Submit** after changing moving average or standard deviation options; they should update automatically. Note the

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seven day lag period before the moving average and standard deviations are displayed; these calculations require seven days of data before they can be computed.

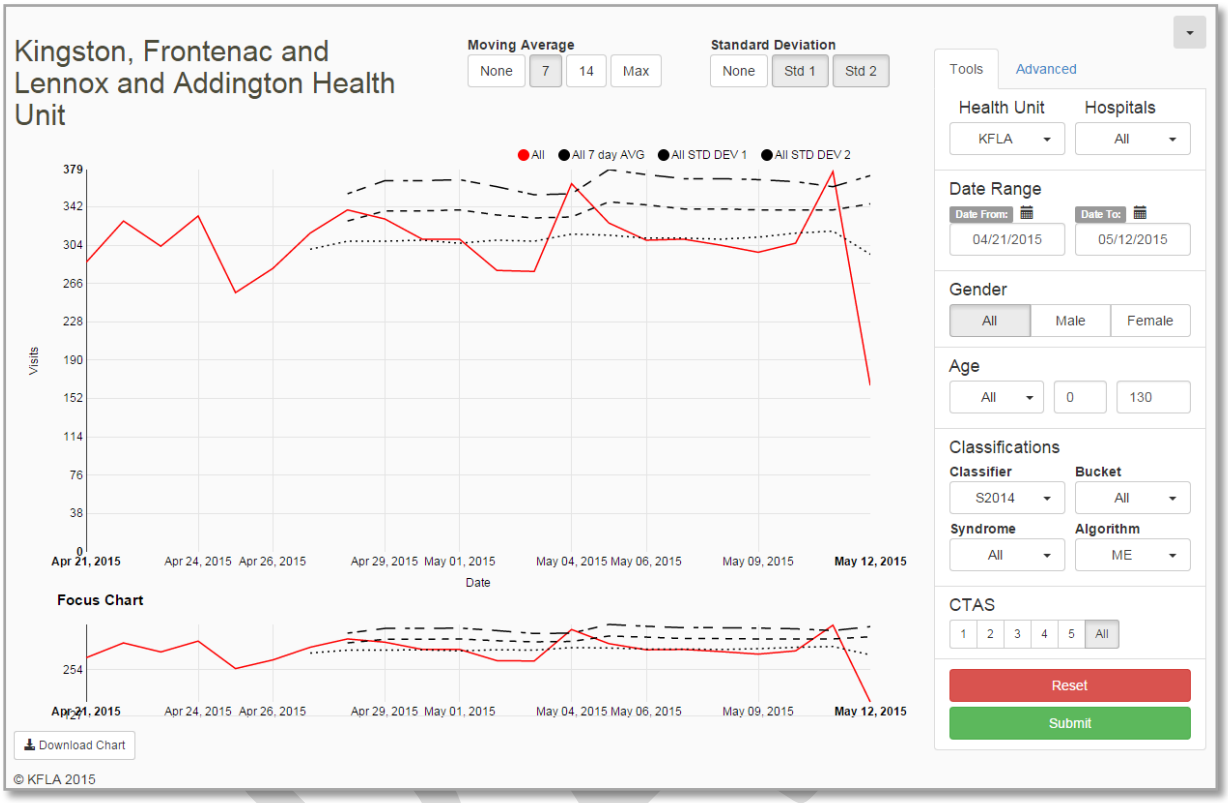

Figure 11. An epicurve example.

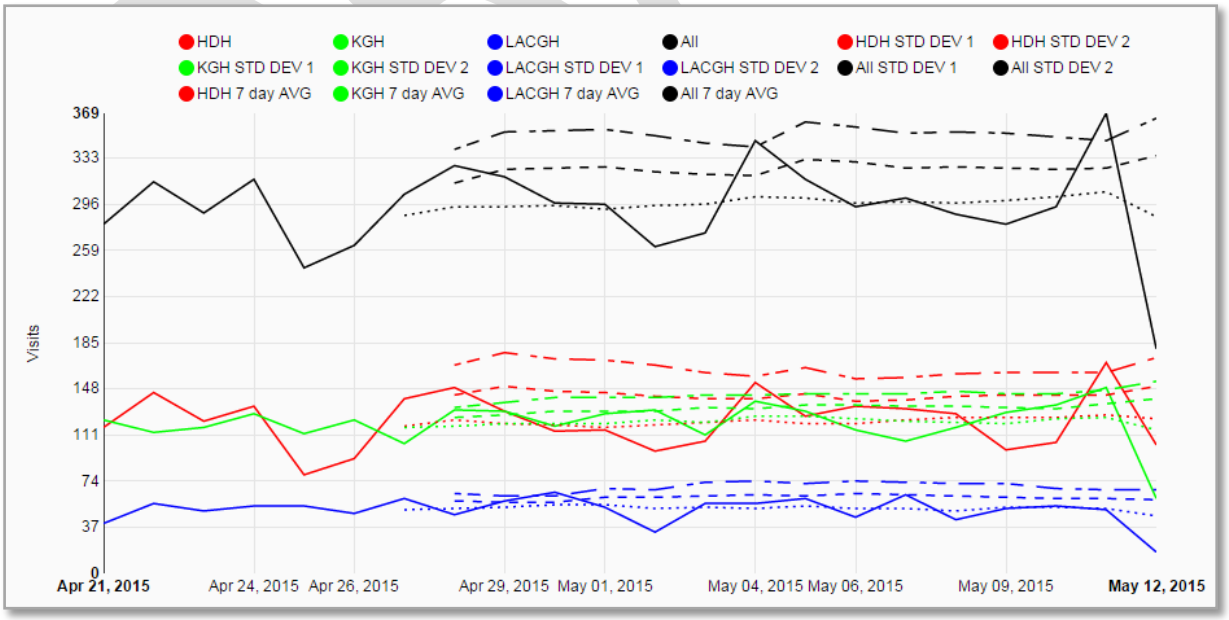

Figure 12. An epicurve example - Local PHU Patients and Hospitals.

In the **Advanced** options tab, the data can be further constrained. For this example, the data is displayed by hospital by choosing **Local PHU Patients** and **Local PHU Hospitals**; this sorts the data to display to just the patients that reside within the PHU region that visited each hospital within the PHU region. In Figure 12, the epicurve is now broken down by hospital in the KFL&A Public Health region. The **black** line represents data from all hospitals combined. The **red** line represents data from Hotel Dieu Hospital (HDH), the **green** lines represent data from Kingston General Hospital (KGH), and the **blue** lines represent data from Lennox and Addington County General Hospital (LACGH). The inclusion of both **Std 1** and **Std 2** make this a busy graph, and can be deselected if desired. To return the graph to its default display settings, click Reset.

2.4.4 Additional Features

2.4.4.1 Focus Chart

A helpful feature for data visualization and exploration is located below the Epicurve: **Focus Chart**. This chart allows the user to adjust the graph to focus on a narrower time period without having to create new graph. When you move your cursor over the Focus Chart, it becomes a large cross. Clicking on the desired date(s) on the **Focus Chart** creates a window that can slide back and forth to either widen or narrow in on the date range (Figure 13). The time range chosen will be displayed in the larger epicurve above the **Focus Chart** box.

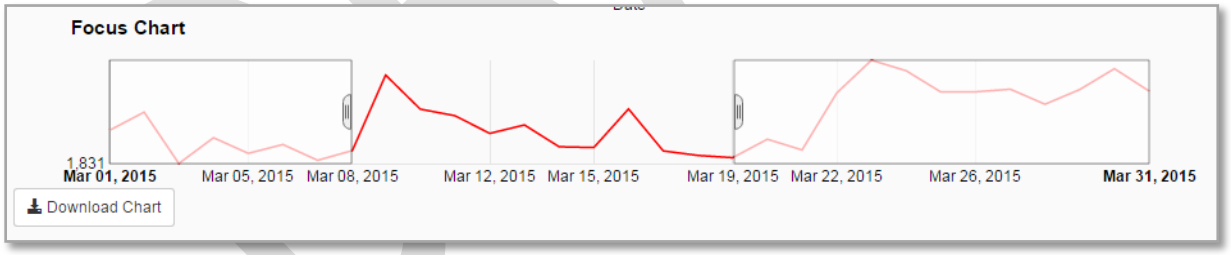

Figure 13. Focus Chart tool.

2.4.4.2 Data Point Display

Hovering the cursor over a point on any of the lines on the epicurve (i.e., visits, moving average, standard deviation) will open a box that displays the date and visit counts for that data point. When viewing a data point from the visit counts (**red solid line**), click to open a window displaying the line listing of the emergency department visits for that day. A description of the information and options available for line listing displays is found in Section 2.5 Line Listings - ED.

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2.4.4.3 Download Chart

At the bottom left corner of the page, you can choose **Download Chart** to download the image as a Portable Network Graphics (PNG) file (see bottom left corner, Figure 13).

2.5 Line Listings - ED

ACES gives you the ability to display emergency department (ED) visits as a textual list with the standard patient information we receive directly from hospitals (i.e., **Date, Time, Admission Type, Age, Gender, FSALDU, Hospital, Syndrome, Complaint, CTAS, EMS Arrival**, and **Patient LHIN).** The main page that opens when you choose **Line Listings - ED** will display the most recent data (that you are registered to view) as individual emergency department visits in descending chronological order for the past week (**Error! Reference source not found.**). Choose the parameters displayed using the dropdown menu from the arrow on the top right corner of the table. You can choose to group according to these parameters as well (see Figure 4 and use the **Group By Icon**).

2.5.1 Line Listings - ED, Tools Menu

To view specific line listings, the **Tools** menu on the right of the screen will guide you in the available options to customize the emergency department visits that are displayed (Figure 14). Selecting **Submit** at any time with generate the Line List with the details provided. Press **Reset** to return all options to their default settings. Each option is described in the following:

- ☑ **Health Unit** and **Hospitals**. The first option allows you to choose the details of the health unit and/or hospitals to be displayed. The availability of these options depends on your data sharing agreement. Hospital users will only have the option to view their own hospitals data. Users from a regional health authority, however, may be able to data from individual hospitals in their region, in addition to the aggregated hospital data.

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- ☑ **Date Range**. Enter the dates of interest as numbers (mm/dd/yyyy format) or choose **Date From** and **Date To** from the dropdown calendars.
- ☑ **Gender**. Choose **Male**, **Female**, or **All**.
- ☑ **Age.** Clicking on the dropdown menu in this section gives six age group options: **All**, **Child** (ages 0 to 17), **School Child** (ages 5 to 17), **Adult** (ages 18 to 64), **Senior** (ages 64 to 130), and **Adult + Senior** (ages 18 to 130). Alternatively, you can manually input the desired age range.
- ☑ **Classifications.** Selecting a specific **Syndrome** from the dropdown menu will list the visit details for patients whose chief complaint was categorized into that syndrome (see more details in Sections 2.4.1.1 Classifications and 3.3 Syndrome Classification using Natural Language Processing). You can also choose to display all syndromes, which will list visit information for all emergency department visits. Under **Classifier**, the dropdown menu gives the option to display syndrome data that was classified using the **S2006** algorithms or the **S2014** algorithms. See Sections 2.4.1.1 Classifications and 3.3 Syndrome Classification using Natural Language Processing for a discussion of these options.
- ☑ **CTAS**. Choose what level of acuity you wish to display.

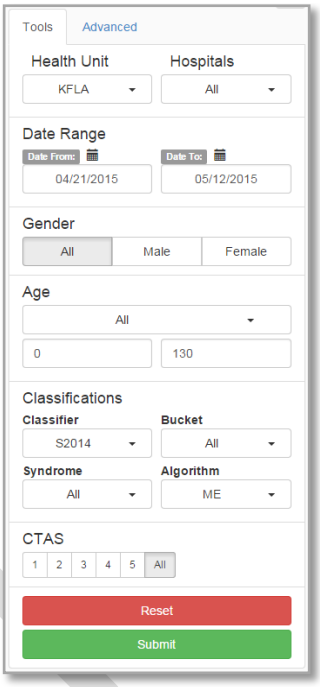

Figure 14. Line Listings - ED, Tools menu.

2.5.2 Line Listings - ED, Advanced Menu

The **Advanced** tab gives you more options regarding the **Locality** (or geography) of either the **Patients** or the **Hospitals** (Figure 15). The extent of options you will have in this tab depends on your data sharing agreement. It is important to note that you must choose **Local** for at least one of the options. Choosing **Local PHU Patients** from the **Patients** dropdown menu will display only patients with postal codes from the PHU's local region, whereas **Province Wide** displays all Ontario patients and **Outside of PHU Patients** displays all patients from outside the PHU's regions (accessing local PHU hospitals). The patient's PHU is determined using the residential

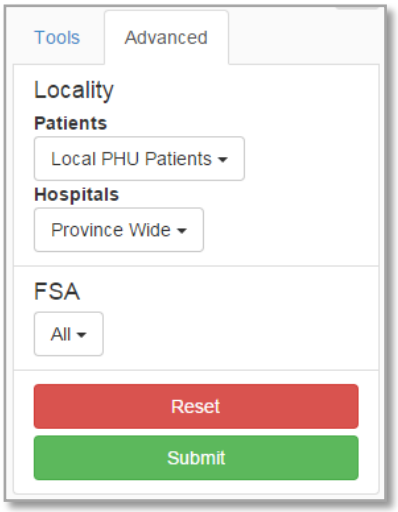

Figure 15. Line Listings - ED, Advanced menu.

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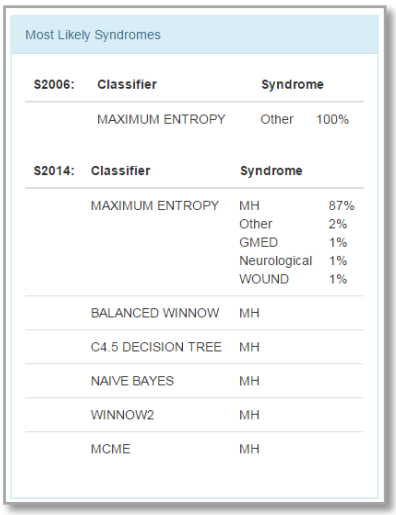
postal code associated with the hospital record. To display local patients accessing specific **Hospital** geographies, choose **Local PHU Hospitals** from the **Hospital** dropdown menu to display local patients using the hospitals within your health units' jurisdiction, choose **Province Wide** for the hospital visits for local patients at all hospitals reporting to ACES, or choose **Outside of PHU Hospitals** for local patients using hospitals outside of the local area. When all display options have been chosen, click the large green **Submit** button. **Reset** will return all parameters to default settings.

2.5.3 Viewing an Individual Line Listing

You may be interested in the details regarding an individual record. Simply place the cursor anywhere on the line describing the record, and click; the full record will open as a separate window. Tabs at the top of the window are for **Details** (see description below), **Alerts** (indicates if this record triggered an alert, is a reportable communicable disease, and the date/time that the alert was reported), and **Metadata** (information specific to storing the data). In the **Details** tab, all information regarding the record is shown, including the following:

- ☑ hospital, hospital PHU and hospital LHIN;
- ☑ admission information (date, time, day of week, week of year);
- ☑ triage information (CTAS, arrival by emergency medical services indicated as **TRUE,** FRI)
- ☑ patient demographics (5-character postal code, county, municipality, LHIN, PHU, CSD, FSA, gender and age);
- ☑ **chief complaint** (transcribed from triage record); and,
- ☑ **Most Likely Syndromes** (Figure 16, see explanation below).

Each individual hospital visit is classified by ACES into a syndrome of medical significance. This process is described in greater detail in Sections 2.4.1.1 Classifications and 3.3 Syndrome Classification using Natural Language Processing. Briefly, ACES employs several classifying algorithms that sort the hospital visits into pre-defined syndromes based on the occurrence of words or phrases in the chief complaint; the results of these classifying algorithms are shown on this page. This page should be consulted before contacting the ACES administrator if you suspect a problem with the syndrome


Most Likely Syndromes

S2006:	Classifier	Syndrome	
	MAXIMUM ENTROPY	Other	100%

S2014:	Classifier	Syndrome	
	MAXIMUM ENTROPY	MH	87%
		Other	2%
		GMED	1%
		Neurological	1%
		WOUND	1%
	BALANCED WINNOW	MH	
	C4.5 DECISION TREE	MH	
	NAIVE BAYES	MH	
	WINNOW2	MH	
	MCME	MH	

Figure 16. Most Likely Syndromes from an individual line listing.

classification for a line listing. For example, in Figure 16 the percentage likelihood is for several different syndromes are shown for maximum entropy from the S2014 Classifier. If the classification of the chief complaint (not shown) for this hospital visit were in question, you could first check here to see if there were other likely syndromes indicated using different algorithms. Remember, you have the option of the algorithm used to sort your data using the **Tools** menu for Epicurves (Section 2.4.1.1 Classifications), Line Listings - ED (Section 2.5.1 Line Listings - ED, Tools Menu) and Line Listings - AD (Section 2.6.1Line Listings - AD, Tools Menu).

2.6 Line Listings - AD

In the same way that ACES enables you to view a textual list of individual emergency department visits, hospital admissions can also be displayed according to the standard patient information associated with these records. Specifically, this information includes **Date, Time, Admission Type, Age, Gender, FSALDU, Hospital, Complaint,** and **Patient LHIN.** Similar to **Line Listings - ED**, **Line Listings - AD** will display the most recent data (that you are registered to view) as individual hospital admission in descending chronological order for the past week. See Figure 17 for an example of admissions line listings. Not that **Admissions Type** includes **Elective Admissions** and **Emergency Admissions**. Admissions are categorized into syndromes in the same manner as emergency department visits (see Section 3.3). Grouping the line listings by **Admissions Type** shows these two categories for admissions; grouping can be achieved using the dropdown menu from the arrow at the top right corner of the table (Figure 18).

EXAMPLE OF LINE LISTINGS - AD,

ADD WHEN SYNDROME CLASSIFICATION COMPLETE.

Figure 17. Example of Line Listings - AD.

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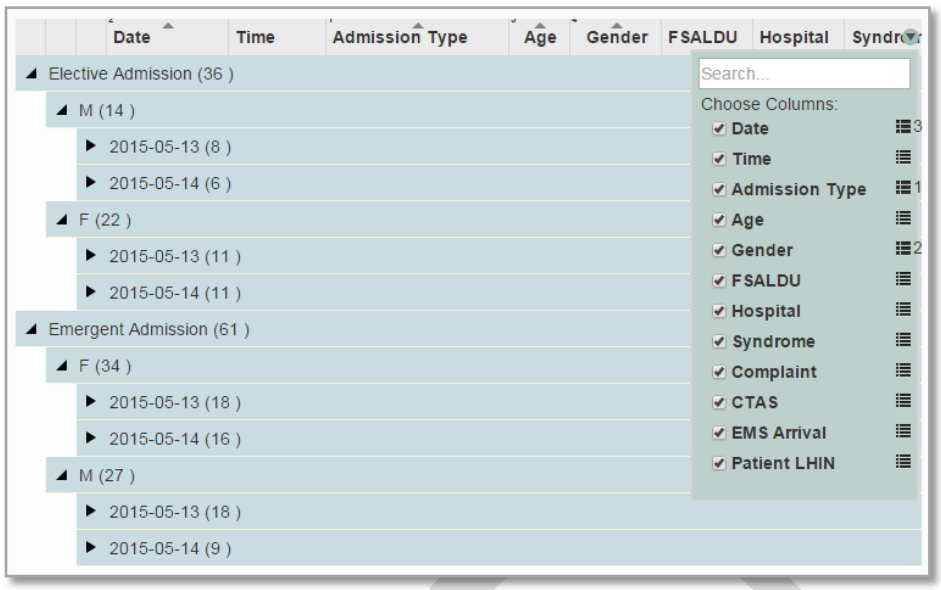

Figure 18. Line Listings - AD, Group By options.

2.6.1 Line Listings - AD, Tools Menu

The **Tools** menu on the right of the screen shows the available options to customize the hospital admissions that are displayed in the line listings (Figure 19). The options available under **Health Unit** and **Hospitals** depend on your data sharing agreement. **Data Range** can be entered manually (mm/dd/yyyy) or by choosing from the dropdown calendars. Choose from the options for **Gender**, **Age** and **CTAS**, and select **Submit** to display the selected admissions. **Reset** will return all settings to their defaults.

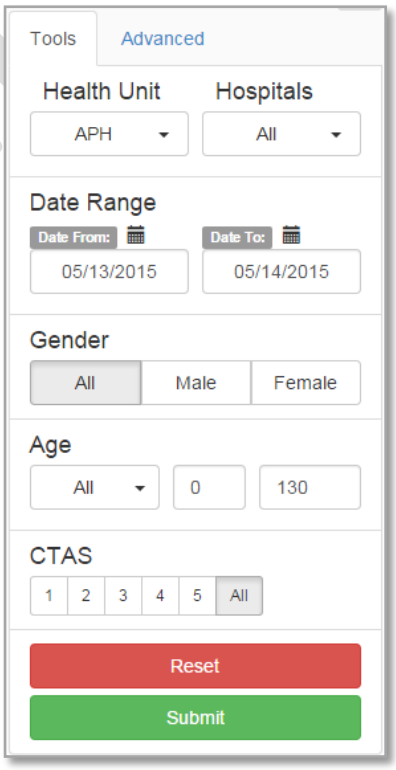

Figure 19. Line Listings - AD, Tools menu.

2.6.2 Line Listings - AD, Advanced Menu

The **Advanced** tab for **Line Listing - AD** gives you the same options that are available for with the **Advanced** tab for **Line Listings - ED**. Please refer to Section 2.5.2 Line Listings - ED, Advanced Menu for instructions.

2.7 Map

Figure 20. Map scale tool.

The **Map** page allows you visually examine the spatial distribution of acute care hospital visits. The first thing you'll see when you select the **Map** tab on the main navigation toolbar is a map of Ontario. To move around the map simply move the cursor over the map, click and drag the map reveal locations you want to view. Likewise, to zoom in or out you can rotate the wheel on your mouse, or move the square on the scale in the top left corner beneath the small house symbol (Figure 20). If you click the house symbol, the map view will be returned to the default zoom and location settings. At the bottom right corner, the location displayed is indicated on a large scale map. Remember that although the map can be moved around to various jurisdictions, only data from Ontario hospitals that are actively sharing data with ACES will be displayed on the map. The main features of the map be manipulated using the tabs displayed on the right side of the screen. Each tab and its options are described in the following sections.

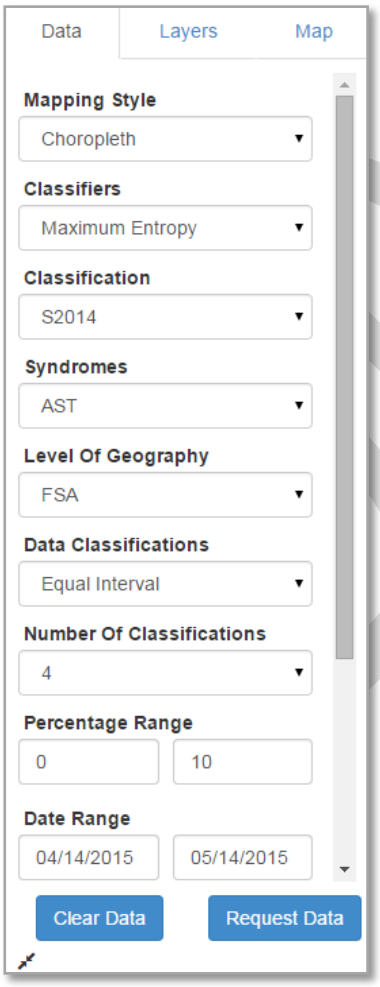

Figure 21. Map Features - Data, menu.

2.7.1 Map Features - Data

The main options for determining the hospital visits to be displayed on the map are found in the **Data** tab (Figure 21). The dark gray scroll bar can be moved to reveal the remainder of the options. In the bottom right corner of the tab is an arrow to reduce or expand the menu. In order for data to be displayed, the various options need to be chosen and **Request Data;** there is no default data display.

2.7.1.1 Mapping Style

You have two choices for how you want the data can be visualized on the map: as **Choropleth** or as **Proportional Symbols**. **Choropleth** displays the variation in the number of hospital visits for each region by variation in colour; darker colours represent more visits than lighter colours (as defined in the legend). An example of a legend for Choropleth display is shown in Figure 22 (**Number of**

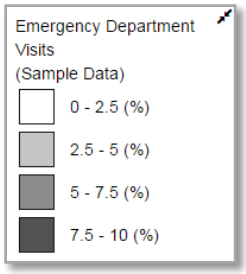

Figure 22. Mapping Style - Chloropleth.

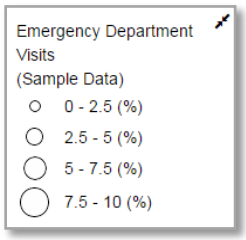

Figure 23. Mapping Styles - Proportional Symbols.

Classifications = 4). **Proportional Symbols**, on the other hand, displays the number of hospital visits as a proportionally sized circle marker on each level of geography (as defined in the legend, see example in Figure 23). Note the small arrow in the top right corner of the legend that can be used to reduce or expand the size of the legend.

For both mapping styles, moving your cursor over a specific region will give more details regarding that region in a pop-up information box. The pop-up box contains information specific to that region: the name of the level of geography requested (i.e., the FSA for the region, the county name, the PHU, or the LHIN), the number of visits for the syndrome requested, the total number of hospital visits, and the percentage of total visits for the selected syndrome (of total visits). Using **Choropleth** the box will appear in any section of the map; with **Proportional Symbols**, you need to place the cursor over the marker.

2.7.1.2 Classifiers

The **Classifiers** drop down menu offers five options for the algorithm used to sort the hospital visits into pre-defined syndromes. Theses classifiers are derived from machine learning applications; more information regarding this process and the choices included can be found in Sections 2.4.1.1 Classifications and 3.3 Syndrome Classification using Natural Language Processing. The default classifier is **Maximum Entropy**.

2.7.1.3 Classification

The **Classification** option allows you to choose to display the data sorted into syndromes using the most recent syndrome lists and algorithms (**S2014**) or using the previous EDSS/RODS system (**S2006**). The older system has been maintained to give you the option to compare your current data to older data and syndrome sorting, which may be applicable to in some circumstances. The default **Classification** is **S2014**. See Sections 2.4.1.1 Classifications, 3.3 Syndrome Classification using Natural Language Processing, and 3.3.5 Syndrome Validation for more information.

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2.7.1.4 Syndromes

A list of pre-defined syndromes is available to choose from under **Syndromes**. If you have chosen **S2014** under **Classification**, these represent the current syndromes that are validated for use with ACES. If you choose the **S2006** classification system, there are only eight syndromes to choose from. See Section 2.4.1.1 Classifications for more information.

2.7.1.5 Level of Geography

The choices for **Level of Geography** include **FSA** (the first three characters of postal code), **County**, **PHU**, or **LHIN**. Data are displayed according to the level of geography chosen.

2.7.1.6 Data Classifications, Number of Classifications and Percentage Range

These options work in concert to display the data in the way that you choose. **Data Classifications** refers to the method used to display the quantities (or proportions) of hospital visits. With the **Choropleth** mapping style, there are three different ways that the data can be classified: **Equal Interval**, **Quantile**, and **Standard Deviation**.

Equal Interval will map the data in an equally distributed gradient based on the normalized values, or percentages, for the selected syndrome and geography. The number of gradients is determined by the **Number of Classifications** chosen. For example, if you choose **Data Classifications = Equal Interval**, **Number of Classifications** = **6**, and **Percentage Range** between **0** and **24**, the legend will have 6 equal gradients of 4% each. When using percentage range, be aware that for each syndrome, percentages can vary; a good knowledge of the syndrome's behaviour is necessary. For example, when mapping the syndrome **RESP** in the summer months, numbers are generally low and **Percent Range** between 0 and 20% should be sufficient to display all the data. In the winter months the upper extreme needs to be increased, as **RESP** visits generally increase proportionally versus total hospital visits at this time, and may be greater than 20% of all visits and would, therefore, not be represented on the map.

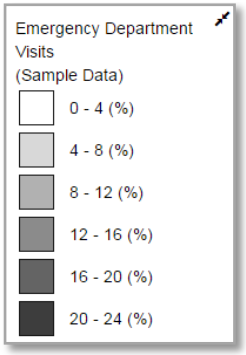

Figure 24. Equal Interval, Classifications = 6, Percent Range = 0 to 24.

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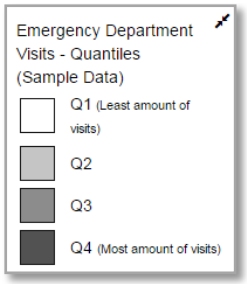

Figure 25. Quantiles, Number of Classification = 4.

Quantile is a more simplistic approach. Choose the **Number of Classifications** (**4**, **5**, **6** or **10**), and the same number of equally sized data subsets will be displayed (quartiles, quintiles, sextiles, and deciles, respectively). For example, if **4** is chosen, the values of each level of geography are divided into fourths, Q1 representing the lowest 25% of the values, Q2 the next 25%, etc. Figure 25 shows a legend for a data display of hospital visits as quartiles.

Standard Deviation is used when you prefer to display the data on the map in reference to the average for the whole province for the selected syndrome, or in comparison to the chosen level of geography. For example, the legend shown in Figure 26 displays the gradients between greater than three standard deviations above (orange) or less than three standard deviations below (royal blue) the mean. **(**ADDITONAL OPTIONS NEED TO BE DISCUSSED)**

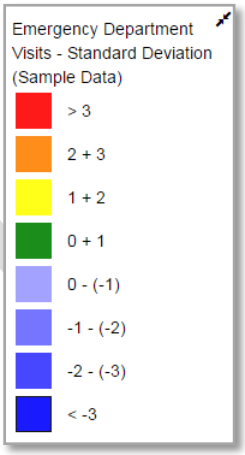

Figure 26. Standard Deviation.

2.7.1.7 Date Range, Gender, Age Group, Age Range

Scrolling down the tab with the dark gray slider will reveal several more choices for data display, including **Date Range**, **Gender**, **Age Group** and **Age Range**. **Date Range** can be entered manually (mm/dd/yyyy) or using the dropdown calendars. **Age Group** include some pre-defined age groups that may be helpful for your analyses.

When all desired parameters are entered, press the **Request Data** button to generate the map. Click **Clear Data** to revert back to the default settings. Please note that you can choose as wide a date range as you want, but it is advised to use ranges of a month or less, as a request for data from larger time periods can take a long time, during which the system may time out and end your session.

2.7.2 Map Features - Layers

The second tab on the right side of the map screen, **Layers**, allows you to add additional information to your map. For example, adding **Daycares** will add all daycare facilities on the map using the symbol indicated. Other **Layers** include pharmacies, PHUs, long-term care facilities, schools, and traffic cameras. Note that you can display multiple layers the map may become cluttered; press **Clear Layers** to clear all layers added.

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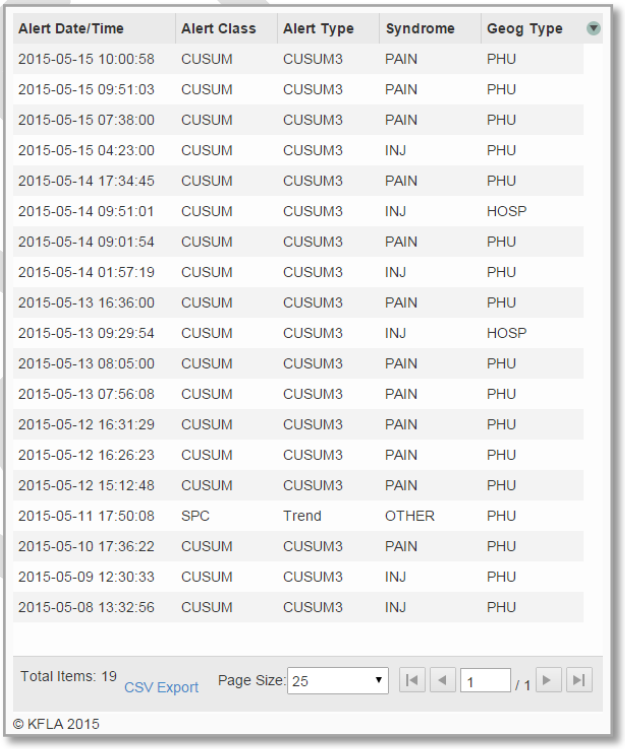
2.7.3 Map Features - Map

The **Map** tab enables different viewing options for the base map. For example, the default setting is ***Topo***, or topographical, which is a mapping style that describes the surface shapes and features. Other choices include **Street**, **Satellite**, **Hybrid**, **Gray**, **Oceans**, **National Geographic**, and **OSM** (©OpenStreetMap contributers). These descriptions are generally self explanatory, and are best explored while using ACES. You can also change the layer and border colours in this tab. Once you have finished customizing the map, press **Update** to change the base map. **Reset** will return the map to its default settings.

2.8 Alerts

One of the main advantages of ACES is its real time surveillance capabilities; mathematical models are used to calculate potentially aberrant patterns in hospital visits and these are presented as alerts. Alerts are then communicated to public health officials or other health care service administrators to examine and confirm. The ability to detect aberrant hospital use patterns in real time may, for example, enable the early detection of a disease outbreak. Alternately, an alert may identify problems with the collection, transmission or storage of data.



Alert Date/Time	Alert Class	Alert Type	Syndrome	Geog Type
2015-05-15 10:00:58	CUSUM	CUSUM3	PAIN	PHU
2015-05-15 09:51:03	CUSUM	CUSUM3	PAIN	PHU
2015-05-15 07:38:00	CUSUM	CUSUM3	PAIN	PHU
2015-05-15 04:23:00	CUSUM	CUSUM3	INJ	PHU
2015-05-14 17:34:45	CUSUM	CUSUM3	PAIN	PHU
2015-05-14 09:51:01	CUSUM	CUSUM3	INJ	HOSP
2015-05-14 09:01:54	CUSUM	CUSUM3	PAIN	PHU
2015-05-14 01:57:19	CUSUM	CUSUM3	INJ	PHU
2015-05-13 16:36:00	CUSUM	CUSUM3	PAIN	PHU
2015-05-13 09:29:54	CUSUM	CUSUM3	INJ	HOSP
2015-05-13 08:05:00	CUSUM	CUSUM3	PAIN	PHU
2015-05-13 07:56:08	CUSUM	CUSUM3	PAIN	PHU
2015-05-12 16:31:29	CUSUM	CUSUM3	PAIN	PHU
2015-05-12 16:26:23	CUSUM	CUSUM3	PAIN	PHU
2015-05-12 15:12:48	CUSUM	CUSUM3	PAIN	PHU
2015-05-11 17:50:08	SPC	Trend	OTHER	PHU
2015-05-10 17:36:22	CUSUM	CUSUM3	PAIN	PHU
2015-05-09 12:30:33	CUSUM	CUSUM3	INJ	PHU
2015-05-08 13:32:56	CUSUM	CUSUM3	INJ	PHU

Figure 27. Alerts, main table.

After navigating to the **Alerts** page, you will see a large table listing all the alerts that have been recorded for the previous two weeks for the data associated with your data sharing agreement (Figure 27). Information included in this table includes **Alert Date/Time**, **Alert Class**, **Alert Type**, **Syndrome**, **Geog** (geography) **Type**, **Geog Name**. Clicking on the grey arrow at the top right corner of the table prompts a dropdown menu that allows you to customize which columns are displayed, as well as **Group By** options (see Figure 18 for an example of the **Group By** function). Click on a column to list the alerts according to those parameters. To further constrain your data display, there is a menu of options shown on the right of the screen. These include **Health Unit** (dropdown options available here depend

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on your data sharing agreement) or **Hospital** (dropdown options will include those hospitals for which you have data access); choosing from these options will limit or expand the data sources displayed in the main table. **Data Range** may be changed to accommodate the dates you would like displayed and can be entered manually (dd/mm/yyyy) or from the dropdown calendars. Finally, all **Alert Type** choices are listed in the menu; check the boxes of those that you wish to display. The default alerts are **Extreme**, **Trend**, and **CuSum3**, as these are the alerts of most epidemiological significance, and therefore concern for the typical ACES user. Fifteen commonly-accessed syndromes are available in this menu as well, with many more choices available in the **More Syndromes** menu. Further explanation of these alerts and the mathematical models used to calculate them can be found in Section 3.4, and syndrome classification can be found in Section 3.3**Error! Reference source not found.**.

For more information regarding a specific alert, click anywhere on its line listing in the table; a graph of the data triggering the alert will be displayed in new window. Depending on the type of alert chosen, various statistical information will be displayed on the graph. For example, the graph in Figure 28 shows

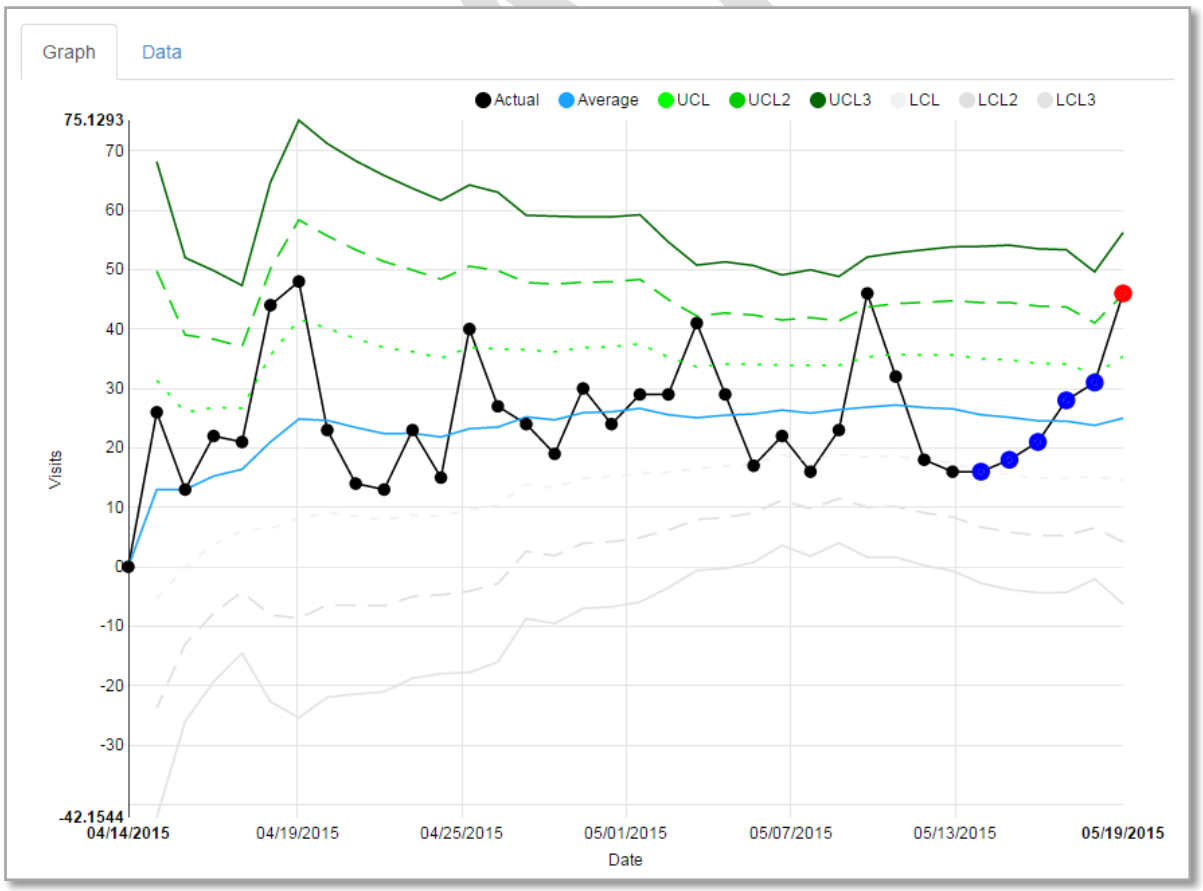

Figure 28. Example of a Trend alert.

the data that triggered a **Trend** alert. Briefly, a **Trend** alert is triggered by the sixth day in a row with increasing hospital visits. The legend at the top describes the various information given: black circles and line for the data points, the average (in this case, a fourteen day moving average), green dotted lines showing the upper control limits (UCL, UCL2 and UCL3, representing the standard deviation, two standard deviations and three standard deviations, respectively), and gray dotted lines indicating lower control limits (LCL, LCL2 and LCL3, representing the standard deviation, two standard deviations and three standard deviations, respectively). The last six data points that caused the alert are shown in blue and red (on the day the alert is triggered). Although there are no points greater than the UCL3, an alert is triggered because the rule has been satisfied for a Trend alert. It is important to note, however, that although this statistical information is included in the graph, a Trend alert is based solely on the last six data points showing an increasing trend, and therefore, each data point's relation to statistical parameters is unimportant. Choosing the **Data** tab at the top right of the graph will show the same data in tabular format.

2.8.1 Alerting Protocols

For a detailed description of all the alerts used with ACES, see Section 3.4**Error! Reference source not found.**. As a first step, ACES users will investigate the alert, and when warranted, pass on the alert via email to the Communicable Diseases (CD) and/or the Environmental Health (EH) teams of the associated PHU (or similar line of notification as per each HU's policies). The specific steps in this investigative process can include (users can also use the Risk Assessment of ACES Alarms tool **Appendix X – need to update**):

1) Confirm the syndrome classification. The individual ED visits that are causing the alert are viewed individually to ensure that the classification corresponds with the chief complaint and/or diagnosis. See Section 2.4 Epicurves.

Note: If the syndrome classification is incorrect of inconsistent, please make note of any discrepancies and contact ACES at kflaphi@kflapublichealth.ca.

2) Plot the cases using the Epicurve function to examine the trend causing the alert. Use the normalize function and the standard deviation and moving average options in ACES to enhance your graph. Note that graphs and cases specific to an alert can also be viewed when clicking on the alert under investigation.

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3) Map the syndrome under review using the **Maps** function to observe the geographic dispersion regarding the cases. Be sure to use different geography levels (eg. FSA, County etc.) to see if syndrome is specific to a small or large area. If clustering is evident, the investigator may examine schools, daycares, long-term care facilities, and other sources of data to help guide next steps.

4) If possible, determine the population that is at risk (e.g., children, the elderly, individuals residing in an area defined by a postal code or FSA, etc) using steps 2 and 3.

5) If an outbreak is suspected, notify the hospital(s), physicians, PHU branch offices and (potentially) other PHUs depending on the scope and if further investigation is required. PHUs can raise awareness amongst the relevant hospital(s) regarding the syndrome in question to enable more efficient diagnosis and to implement necessary and appropriate precautions, such as infection control procedures. The hospital(s) may also provide additional information to aid the investigation, such as identifying additional cases.

   The Hospital Infection Control Practitioner (ICP) or designate Infection Control staff member is the contact for the PHU at the hospital. The call Nurse on the floor may be contacted for information pertaining to admitted patients. Please ensure that all relevant information (e.g., date/time of visit, hospital, number of cases, comparison to seasonal trends, lab data if available, etc.) is ready at the time of the call to ICP or designate to facilitate efficient investigation. NOTE: Lines of communication between health unit and the health care system is an important part of this process. It is suggested that all users have a predefined internal process to connect with these outside stakeholders to efficiently coordinate investigation and follow-up.

6) If deemed appropriate, contact the hospital's laboratory (for acute care visits or admitted patients), Public Health Laboratory (for samples related to outbreak investigation and tests outlined on the Ontario Public Health Laboratory Test Directory), and/or private laboratories to request number of test requisitions, positive results (preliminary or otherwise), negative results, type/species identification, etc that may be associated with the syndrome under investigation.

7) Continue to monitor ACES for real-time emergency department visits and admissions of the syndrome of interest, particularly the spread of disease, geospatial analysis, changes in patient demographics and disease severity (CTAS levels). Contact hospital(s) as required.

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2.8.2 Suggested Procedure for Respiratory or Gastrointestinal Outbreaks in the Community

1) As a first step, Public Health staff will be notified via telephone call, fax, and/or mail from a laboratory, an institution such as long-term care of daycare, physician, etc. of an infectious disease event requiring further investigation. In most cases, this notification is concerning a reportable disease, which must be reported by law to Public Health. Public Health investigation is warranted for most reportable diseases, unusually high incidence of disease (particularly in institutions), new or emerging diseases or any other infectious disease event deemed to be a threat to the health of the public. Notification may come to any of the appropriate CD or EH team members during regular business hours Monday to Friday, 8:30 am to 4:30 pm, or to the Medical Officer of Health or assigned back-up during evenings and weekends.

2) ACES may be utilized in addition to standard investigative processes as follows:

- ☑ Following notification to Public Health, access ACES to examine the syndrome of interest, time period, demographics and location of interest as described above. One of more of these features may be explored individually to characterize the potential outbreak.
- ☑ Use **Epicurve** and/or **Map** to display the necessary information.
- ☑ Contact the relevant health care facility for additional cases and observations.
- ☑ Notify the hospital(s), physicians, PHU branch offices and (potentially) other PHUs depending on the scope of the outbreak and if further investigation is required. PHUs can raise awareness amongst the relevant hospital(s) regarding the infectious disease to enable more efficient diagnosis and to implement necessary and appropriate precautions, such as infection control procedures.
- ☑ Monitor ACES on a regular basis to assess real-time hospital visits for the syndrome of interest using **Epicurve** and **Map** to track changes in disease patterns.

2.9 Frequently Asked Questions

2.9.1 Q1 - Why did my Map request crash/time out?

When all desired parameters are entered, press the **Request Data** button to generate the map. Click **Clear Data** to revert back to the default settings. NOTE: You can choose as wide a date range as you

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want, but it is advised to use ranges of a month or less, as a request for data from larger time periods can take a long time, during which the system may time out and end your session.

2.9.2 *Q2 - When comparing the old syndromes running in EDSS/RODS to the data in ACES for the same syndromes, there seems to be discrepancies, why is that?*

There are a few contributing factors to why this is the case. 1) There are hospitals in ACES that have not been put in RODS. If patients from your HU went to these hospitals they would not be counted in RODS. 2) ACES has the ability to assign any Ontario postal code to a HU but that was not the case in RODS. RODS did not have the power for us to just include all of our postal code iterations so whenever a new HU was added we used their historic data to add roughly the top 20 codes in terms of frequency so that a majority of visits would be counted but there was always the possibility that some visits would not be counted. Suffice to say ACES is more accurate and is counting each and every visit and assigning it to one of our 36 health units. If the patient is not from Ontario they are still counted but would be under the hospital count as a non-local resident. These instances you can also count in ACES but you weren't able to do that in RODS.

2.9.3 *Q3 - If we use the new syndromes in our reporting is there an easy way to get historical data for comparison?*

While we did provide a reporting function in EDSS/RODS that allowed you to download two years of historic data for your local hospitals we are not offering that in ACES. We have built ACES in a way that this should not be necessary. Graphing HU data and data by hospital and then downloading a jpeg file or screen capture of the graph you created should erase the need for data dumps and having to create graphs on your own in Excel.

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3 THE SCIENCE OF ACES

3.1 A Short History of Syndromic Surveillance

Syndromic surveillance has its origins in epidemiologic surveillance—the traditional systematic collection, evaluation and dissemination of health information. Traditional surveillance methods can be passive (e.g., regular disease reporting to public health authorities or other administrative means) or active (e.g., gathering disease information from a population through surveys). Syndromic surveillance is a distinct form of passive surveillance, in that information regarding a predefined syndrome (i.e., a particular disease, condition or injury) is monitored for a specific population. This form of surveillance is of particular value for assessing (or predicting) disease outbreak, such as influenza. Examples include the monitoring of absenteeism logs from school or work settings, over-the-counter drug sales, internet search data (such as Google Flu Trends), or emergency department triage records (such as ACES).

Syndromic surveillance drew attention, and consequently (?) increased research interest, during the perceived threat of terrorism, particularly bioterrorism, following 9-11 in 2001. The occurrence of pandemic threats (e.g., SARS from November 2002 to July 2003) secured the utility and value of real-time syndromic surveillance beyond bioterrorism, as public health agencies recognized inadequacies in emergency preparedness and the need for enhanced surveillance techniques (e.g., the Walker Report, the Naylor Report, the Campbell Commission). Methods for the early detection of intentional poisoning of water or food, for example, were needed in real-time to ensure rapid treatment and allocation of resources. These same methods would be useful for monitoring a growing list of possible threats to both individual and public health, such as influenza outbreaks, the health effects of climate change (e.g., increased extreme weather), specific causes for injury and asthma, and clusters of health effects related to illicit drug use.

Electronic data collection has led the way for modern syndromic surveillance systems to provide efficient, sensitive, and near real-time capabilities to detect and statistically analyze aberrations from historical trends. Geospatial analytics allow for visualization of these trends at regional, national, and global levels. Assuming that aberrations are detected in a timely manner, reasonable public health measures can potentially minimize adverse health outcomes; the addition of geographical information allows for population-specific interventions. Interventions might include but are not limited to, the reallocation of health care resources to high-risk populations, public health reassurances and health care

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recommendations. For example, if a syndromic surveillance system indicates that there is heightened influenza risk within a specified region, dedicated clinics can be opened to treat patients, possibly reducing patient influx into local acute care facilities where resources are often already overextended, and reducing transference of disease.

Several factors are essential for an efficient syndromic surveillance system: (1) routinely collected for other reasons (e.g., administrative) to reduce costs and staffing, (2) recorded and accessible electronically, and (3) available in near real-time. The described and defined syndromes need to be validated using traditional data sources (e.g., laboratory results, physicians' diagnoses). In general, syndromic surveillance systems based on emergency department records are easily made compliant to these constraints. Of all possible sources for electronic medical records, acute care triage records submitted at patient registration provide the most potential for truly real-time surveillance; emergency departments are open twenty-four hours per day, every day of the year, allowing a wide-range of potential patients to access acute care services for an equally wide range of reasons.

3.2 The Development of ACES

In September of 1999, researchers at the University of Pittsburgh initiated the prototype Real-time Outbreak and Disease Surveillance (RODS) system to monitor and characterize illness outbreaks using data from electronic emergency department triage reports. The success of this system, combined with the timeliness of its initiation immediately before 9-11, helped it evolve into a much larger surveillance network. It was used to monitor illness and possible outbreaks during the 2002 Olympic Games in Salt Lake City, and has been deployed by several cities and US states to monitor both disease outbreak and pandemic. In August of 2003, RODS was made freely available as open source software. RODS categorizes emergency department visits using free text input from chief complaints included in electronic triage reports, information that is regularly collected at virtually all emergency departments for administrative purposes. Probabilistic algorithms categorize free text words or groupings of words into pre-defined syndromic classes. The earliest RODS syndromes reflect its origins in monitoring for bioterrorism: (1) gastrointestinal—nausea or vomiting, diarrhea, abdominal pain/cramps/swelling , (2) constitutional—non-localized systemic complaints, including fever, faintness, lethargy, (3) respiratory—congestion, cough, sore throat, asthma, pneumonia, (4) rash—any description of a rash, (5) hemorrhagic—bleeding from any site, (6) botulinic—ocular abnormalities, difficulty speaking and swallowing, (7) neurological—non-psychiatric complaints, and (8) other—pain or process in system/area

not monitored by RODS (descriptions from Chapman et al. Art Int Med 2005;33(1):31 doi:10.1016/j.artmed.2004.04.001)

The current ACES system has been developed from RODS, and was first called the Emergency Department Syndromic Surveillance (EDSS) system. It was initiated in September 2004 as a two-year collaborative pilot project between the Public Health Division of the Ministry of Health and Long Term Care, KFL&A Public Health, Queen's University, the Public Health Agency of Canada (PHAC), Kingston General Hospital and Hotel Dieu Hospital. The EDSS system used open-sourced RODS (v3.0) software to categorize ED triage CCs from the participating hospitals, collected in near real-time. Major modifications to the RODS software included the addition of geospatial mapping, alert optimization, syndrome classification, and other changes to the user interface, such as CTAS and FRI screening results. As in the RODS system, key words, phrases and parts of words/phrases found in CCs are used to classify each ED visit into pre-defined syndromes. The initial syndromes were (1) gastroenteritis, (2) fever/influenza-like illness (ILI), (3) respiratory, (4) dermatologic infectious, (5) severe infectious, (6) asthma, (7) neurological infectious and (0) other (included all CCs not otherwise classified and accounted for the majority of ED visits). Results were aggregated and displayed using tables, graphs and maps, and statistical aberrations (alerts) were detected as results above expected historical thresholds.

During the initial two-year pilot project, an outbreak of *Salmonella enteritidis* in November and December of 2005 provided a pragmatic illustration of the effectiveness and value of the EDSS system. At the time, the EDSS was operational with only the hospitals within the KFL&A Public Health catchment area. Use of the EDSS allowed for real-time monitoring and identification of patients faster than would have occurred previously, as well as a faster linkage of front-line health workers to the suspected cases for identification of the outbreak vector. The EDSS system clearly facilitated faster response from, and better communication between, both public health and acute care workers. For a more detailed discussion of these results, see CJEM 2008; 10(2):114-9.

EDSS researchers presented results verifying and validating the EDSS system for respiratory illnesses with the both the National Ambulatory Care Reporting System (NACRS) and Telehealth Ontario (Emerg Inf Dis 2009;15(5):799). Very strong Spearman's correlations between the ED visits categorized as respiratory illness with both Telehealth results (r = 0.91) and NACRS (r = 0.98), confirming that the EDSS provides timely data collection and surveillance of respiratory illnesses. Expanding upon these results, the efficiency of the EDSS system over primary care sentinel surveillance, for example, is described in a paper from 2013 (Can J Inf Dis Med Microbiol 2013;24(3):150). The authors report on using ED visits

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categorized by the EDSS as either ILI or respiratory as a proxy for the detection and prediction of actual lab-confirmed cases of respiratory viral diseases and ILI. Most interestingly, this study spanned the increased ED volumes observed during the H1N1 pandemic in the fall of 2009. The specific syndromes were defined from key words found in recorded CCs: for respiratory illness, “cough”, “sore throat”, “upper respiratory tract infection”, and “sinus infection” were used; for influenza-like-illnesses, “fever” and influenza-related symptoms were used. The results were aggregated weekly from the EDSS and compared to lab results. Significant correlations were measured for selected respiratory viruses and emergency department visits; pH1N1 was the most closely associated with hospital visits, and a general lag time of about two weeks was found between the acute care data and test results.

In 2014, the EDSS system was overhauled to reflect both the expansion of the participating hospitals across Ontario, and the development of additional and more specific syndrome classification. At the same time, numerous technological improvements were made. To reflect these changes, the system was renamed Acute Care Enhanced Surveillance (ACES). The number of hospitals participating in ACES has increased to more than 81% of Ontario hospitals (see Appendix EAPPENDIX E - ACES Participating Hospitals), and we anticipate that over 85% of all Ontario EDs will be participating in ACES by the end of 2015. The list of syndromes has been expanded to a comprehensive list of over 80 health conditions (APPENDIX C - ACES Syndromes). The technological changes to ACES include improved and more epidemiological assessment tools such as:

- ✓ improvements in algorithms for more accurate syndrome classification;
- ✓ more intuitive graphing capabilities;
- ✓ built-in calculations of standard deviations and moving averages;
- ✓ monitoring capabilities have been updated to reflect real-time values instead of arbitrarily fixed intervals; and,
- ✓ visit and/or admission volumes based on either (a) hospital location or (b) patient address.

3.3 Syndrome Classification using Natural Language Processing

To understand the methods used to classify the chief complaint (CC) text into specific syndromes, some concepts of machine learning need to be explored. Machine learning deals specifically with the construction of classification algorithms that can learn from data. ACES uses natural language processing (NLP) algorithms, which are those algorithms designed to enable a computer system to understand

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human text. NLP algorithms are used in daily life, from the spam detector of your email program to the automated online assistant that pops up in your browser when you access certain web pages.

NLP began in the 1950s at the intersection of artificial intelligence and linguistics. Initially, it was considered a quest towards automatic translation, with much emphasis on translating Russian into English reflecting its roots in the Cold War. The task proved much more difficult than expected; simple hand-written rules of direct, word-for-word translation are not sufficient due to the complex, unrestricted and ambiguous nature of language. NLP must extract meaning from text, and deal with spoken or written prose that is not grammatically correct. Out of these restrictions, statistical NLP methods developed, with probabilistic approaches that replace numerous detailed rules with statistical frequency information. The algorithms are refined, or able to learn, through training the program with large amounts of data with the correct answers, and then testing the robustness of the system with an unknown data set, and then repeating until the system performs satisfactorily. The algorithms do not rely on key word searches, but rather probabilistic decisions based on attaching learned weighted values to each word, part of word, or phrase in the CC. The algorithms do not supersede hand-written rules, but are complementary.

Medical records are a particular challenge for NLP algorithms. CCs, for example, are written to be concise descriptions of the reason for a visit to the emergency department; therefore, CCs are often written with abbreviations, context-sensitive vocabulary, idiosyncratic or hospital-specific nomenclature, and often misspellings occur under the inherent demanding conditions in acute care settings. Furthermore, a single symptom may be observed for several possible diagnoses. For example, fever is associated with numerous conditions. Despite these limitations in diagnostic precision, CCs are of critical value to syndromic surveillance; CCs are available in real-time, whereas vetted diagnostic codes (e.g., most reasonable diagnoses codes, MRDx, using ICD-10CA coding) are often not available for several days to weeks for an individual record.

The original EDSS system, based on the early RODS system, used only one type of NLP algorithm, Naive Bayes (NB), to categorize the emergency department visits into its eight syndromes. RODS' NB text classifier was called the Complaint Coder (CoCo), and was found to be problematic in two key ways: (1) the algorithm classifies using just single words, not phrases, and (2) the NB system assumes statistical independence between words in the CC. In 2006, a new classifier was developed for use with the EDSS' the new classifier was based on a Maximum Entropy (ME) model, and analyzes the occurrence of character sequences rather than whole words. In 2014, the EDSS was rebranded as ACES, and now

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computes and displays the results of several text classifiers in addition to its default algorithm ME. These are Balanced Winnow (BW), C4.5 Decision Tree (C4.5), NB, Winnow2, and Monte Carlo ME (MCME). These algorithms are based on the MALLET Machine Learning Toolkit, open-source software developed at the University of Massachusetts, Amherst. In the ACES system, the resulting classification for each algorithm can be displayed, but the default algorithm is ME. Distinguishing features of each algorithm will be described in the following sections.

3.3.1 Naive Bayes

The original text classifier used by EDSS, and developed by RODS, was based on the Naive Bayes (NB) algorithm. In comparison to other text classifiers, NB classifiers use the simplest mathematics, require relatively less resources in terms of computational power (i.e., CPU and memory) or otherwise (i.e. training time, size of training dataset), and are amenable to coding in all standard programming languages. They are based on the conceptual framework of Bayesian statistics; in contrast to the inductive reasoning of frequentist statistics, Bayesian statistics approach probabilities as independent hypotheses in a deductive manner. For example, a NB text classifier treats each term (i.e., word, word portion, or phrase) within the phrase being classified as independent variables. NB classifiers tend to perform very well in many complex real world problems, despite this oversimplification, and are used in a variety of familiar text classification techniques, including sentiment and spam detection, email sorting, and the detection of sexually explicit content.

3.3.2 Maximum Entropy

Maximum Entropy (ME) is the default text classifier used by ACES. Unlike NB, ME text classifiers do not assume the terms are independent of each other. The ME classifier is particularly useful when nothing is known regarding the prior distributions of categories, and the terms cannot be assumed to be independent, as is the case for the categorization of the words and partial words in CC. The ME algorithm computes many different probabilities for the association of the terms, and chooses the class selection that has the highest associated entropy, or the largest probability distribution. ME has a wide range of applications, such as sentiment analysis, language detection, and topic classification. Although ME takes more training time than NB, it generally provides robust results and is competitive in terms of resource use to NB.

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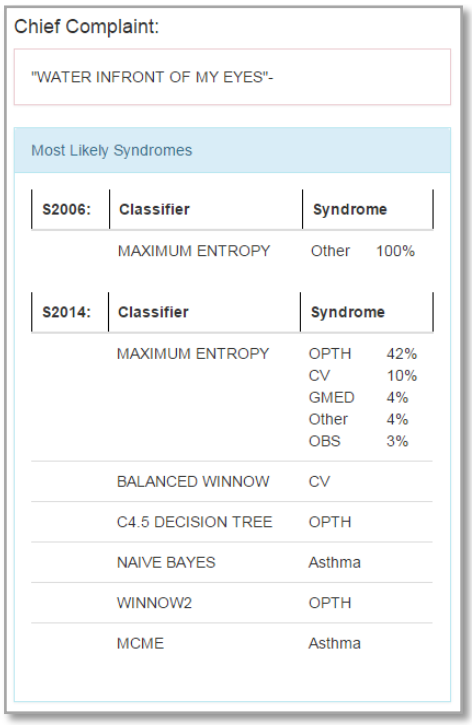
3.3.3 *Balanced Winnow, C4.5 Decision Tree, Monte Carlo Maximum Entropy and Winnow2*

Although the default classifier employed by ACES is ME, the data can be sorted using several additional NLP algorithms. Balanced Winnow (BW) is a simple NLP algorithm that learns from training data (i.e., labelled examples) and uses a multiplicative scheme for probabilities that lends itself well to accounting for many dimensions of information that is irrelevant; BW scales well to high dimensional data. C4.5 Decision Tree (C4.5) is a statistical classifier that is a sequence of branching comparisons; at each intersection, the probability of either branch is calculated and a decision is made towards classifying the ED visit into a single syndrome. Monte Carlo Maximum Entropy (MCME) is a variation on ME, so named for the particulars regarding the calculation methods used to determine probability. Winnow2 is one of many variations of BW in which slightly different methods are used to determine defined iterative values.

3.3.4 *Algorithm use in ACES*

Several NLP algorithms are used to classify the ED visits into syndrome in ACES; ME is used as the default algorithm due to its robustness with similarly complicated applications. As previously stated, RODS used NB and the EDSS system used ME; to provide continuity and comparability between the various iterations of ACES, the technical support necessary to use the different algorithms is maintained in ACES. To that end, the results of the additional algorithms can be displayed as well (i.e., BW, C4.5, MCME and Winnow2). Provision of results by several different NLP algorithms enables an assessment of the strength of the classification; we display the most likely syndrome using multiple classifiers so that end users may better understand chief complaints that classify easily and for which we have high confidence. The user can consider the difference between all six classifiers unanimously predicting the same most likely syndrome with high probabilities versus all six classifier predicting different syndromes with relatively low probabilities.


Chief Complaint:

"WATER INFRONT OF MY EYES"-

Most Likely Syndromes

S2006:	Classifier	Syndrome	
	MAXIMUM ENTROPY	Other	100%

S2014:	Classifier	Syndrome	
	MAXIMUM ENTROPY	OPTH	42%
		CV	10%
		GMED	4%
		Other	4%
		OBS	3%
	BALANCED WINNOW	CV	
	C4.5 DECISION TREE	OPTH	
	NAIVE BAYES	Asthma	
	WINNOW2	OPTH	
	MCME	Asthma	

Figure 29. Results for all NLP algorithms.

To demonstrate the use of the various classifiers, consider the example of a chief complaint shown in Figure 29. The

chief complaint, “water infront [sic] of my eyes”, describes a symptom that may underlie several different medical conditions but is likely related to ophthalmology. Using the s2006 classifier (ME), **Other** is selected. With the s2014 classifier, there are several different results depending upon the classifier. The results for the ME classifier includes a list of possible syndromes in descending order of statistical importance: the most likely syndrome is **OPTH** (general ophthalmological condition), but **CV**(cardiovascular), **GMED** (general medical admission), **Other** and **OBS** (related to obstetrics) all merited appreciable statistical results. Using the alternate classifiers, BW determines the syndrome to be **CV**, C4.5 and Winnow2 corroborate the results of ME as the syndrome **OPTH**, and NB and MCME would classify this chief complaint as **Asthma**. A quick read of the chief complaint makes it obvious that the problem is likely related to an ophthalmological issue. The list of syndromes for the s2006 classifier is not sufficiently comprehensive to properly classify this ED visit. On the other hand, the s2014 classifier appears to have classified the chief complaint correctly into **OPTH**. The inclusion of the results for the alternate classifiers adds power to this classification: the highest ranking syndrome using ME is OPTH at 42%, and although the other rankings have much lower statistics of likelihood, the choice of **OPTH** is supported by two other algorithms. The inclusion of the results of all algorithms also allows for the examination of classification results on an individual hospital visit basis, if necessary.

3.3.5 Syndrome Validation

The ACES system uses NLP to sort each hospital record into a specific and medically-relevant syndrome; some syndromes are used to monitor communicable diseases and other syndromes reflect hospital visits for medical conditions reflecting social or environment factors that may affect the health of the community. The default algorithm for syndrome categorization in ACES is ME, but you can choose to sort your data by several other algorithms (i.e., BW, C4.5, MCME and Winnow2). Classification proceeds using the free text of the CC registered by triage nurses when the patient first arrives in an emergency department. Using CCs to make real-time assessments of population health leads to numerous complications: chief complaints tend to be very brief, and include jargon, idiosyncratic short forms and spelling mistakes. Furthermore, CCs are the triage nurse’s interpretation of a patient’s reason for visiting the emergency department, and do not necessarily reflect the final diagnosis; it is very difficult to diagnose underlying conditions from the presentation of non-specific symptoms. To ensure that ACES syndromes are meaningful aggregates of CC, it is important to measure the accuracy of the diagnoses that the classifier is predicting. To do this, we compare the ACES data to retrospective acute care “gold standard” data available through the National Ambulatory Care Reporting System (NACRS), the national

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repository for acute care data in Canada. Data collected by NACRS is rigorously maintained and checked for accuracy. It is not available in real-time, and therefore all validations are made with retrospective data.

Validation of the syndromic categorization is made by correlating the daily number of emergency department visits categorized into a specific syndrome with its corresponding time series of diagnostically-defined data compiled by NACRS. Standardized diagnostic codes are made by Canadian hospitals using the International Classification of Diseases -10-CA (ICD-10-CA) coding system. ICD-10-CA codes are recorded by the attending physician (or other health care professional) after the patient has been examined (and treated, when applicable). Hospital coding personnel are trained to ensure consistency in coding between hospitals, and there are specific codes for disease, injury, causes of death, as well as external causes of injury and poisoning.

When comparing ACES data to the NACRS datasets, Pearson correlation coefficients are used to describe the relative similarity between the datasets by day for and weekly, bi-weekly or twenty-eight day moving averages. In some cases, where there are relatively few observed cases, monthly cumulative sums must be used in order to have sufficient sample sizes for comparison. Pearson correlation values between 0 and 0.25 indicate poor correlation, values from 0.25 to 0.5 indicate moderate correlation, values from 0.5 to 0.75 indicate good correlation and values >0.75 indicate excellent correlation between datasets. These numbers roughly correspond to the percent of variation in one dataset that can be explained by variation in the second dataset.

3.3.5.1 Examples of Syndrome Validation

Word clouds were used in our validation process to show our users which free text words were most common in each of our validated syndromes. The word cloud shown in Figure 30 represents the relative frequency of single words abstracted from chief complaints that relate to respiratory-related health conditions. The words are selected

Figure 30. Word cloud for Respiratory.

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through the NLP techniques described in Section 3.3. Thus, the words “cough”, “throat” and “sore” occur more often than “travel” and “urti” in our Respiratory syndrome classifications.

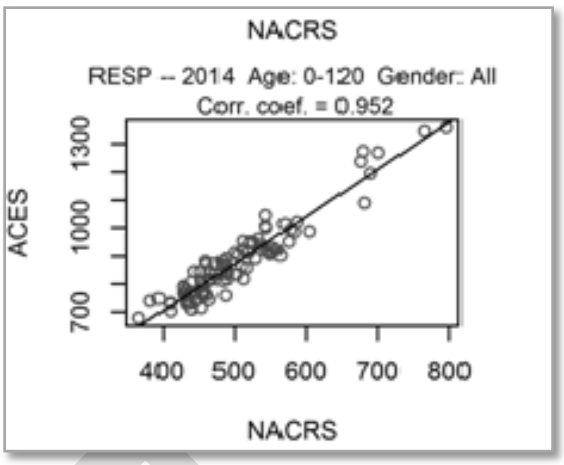

Figure 31. Calculation of Pearson correlation coefficient for Respiratory.

Figure 31 shows the correlation between the emergency department visits that are classified into the Respiratory syndrome and the retrospective NACRS data for the same time period. Diagnostic codes used to extract data from NACRS are shown in Table 1. Excellent correlation statistics (0.952) are observed for all ages and all genders. Thus, we can say with certainty the trends observed in Respiratory reflect the extent of diagnoses for the medical conditions that Respiratory represents.

The validation statistics for the most commonly used syndromes are shown Table 2. Validation statistics will be re-run regularly for the syndromes available in ACES.

Table 1. ICD-10CA codes used to extract NACRS data for validation of Respiratory.

ICD-10 CA	Medical Diagnosis
J00	Acute nasopharyngitis [common cold]
J01	Acute sinusitis
J02	Acute pharyngitis
J03	Acute tonsillitis
J04	Acute laryngitis and tracheitis
R05	Cough

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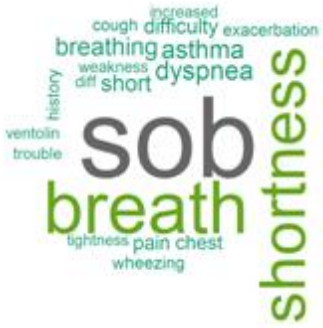
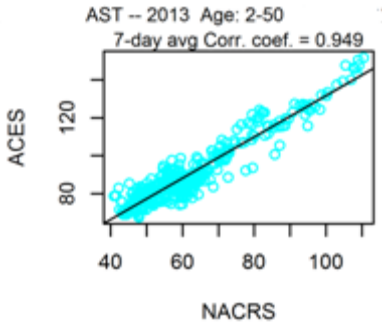
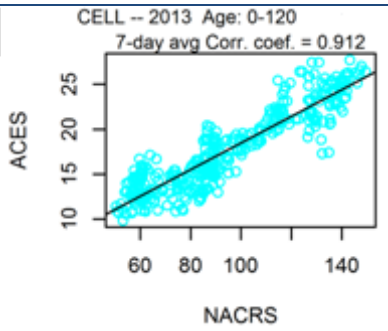
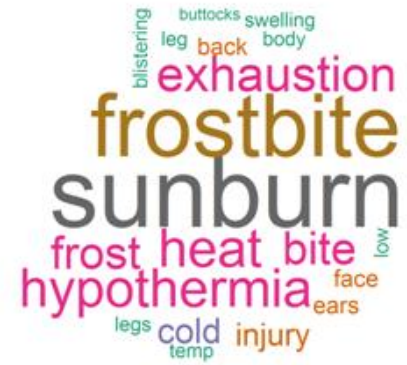
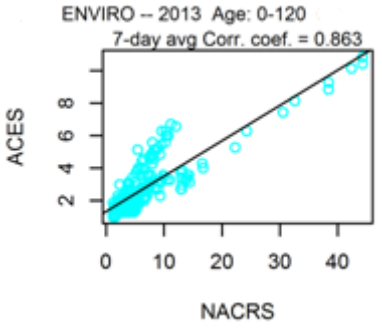
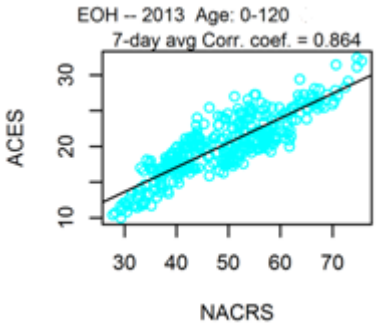
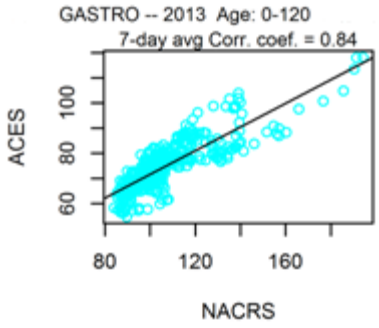
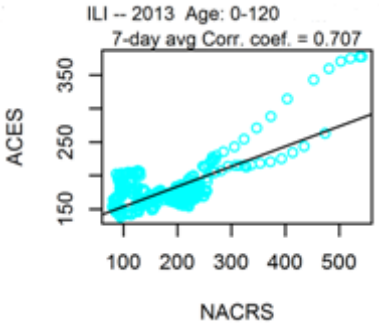
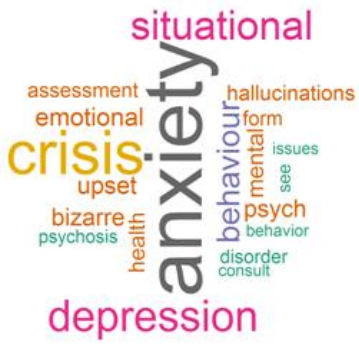
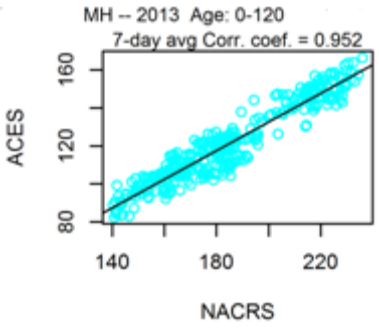
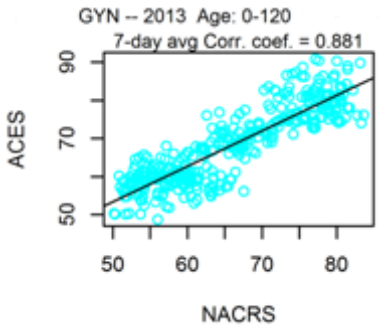
Table 2. Word Cloud and validation statistics for common syndromes.

Syndrome	Words Cloud from CC	Correlation	Visual Representation NACRS v. ACES
Asthma		0.949	
Cellulitis		0.912	
Environmental		0.863	
Alcohol (EtOH)		0.864	

Syndrome	Words Cloud from CC	Correlation	Visual Representation NACRS v. ACES
Gastro		0.84	
ILI		0.707	
Mental Health		0.952	
Gynocological		0.881	

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3.4 Alerts and Outbreaks

According to the Center for Disease Control, the aim of syndromic surveillance is to identify unusual disease clusters through the detection of syndromic, early symptomatic cases, allowing outbreak detection that is earlier in time than would otherwise occur with conventional reporting methods (CDC 2004). Standard disease surveillance techniques include modelling disease incidence and prevalence, as well as the geographical distribution and the spread of disease. With the ability to automate disease and even syndrome-specific data, the current interest is to collect data in real time and at regular intervals, in order to quickly detect important changes in the data series and facilitate timely public health interventions. ACES fulfills both of these constraints: (1) automated and validated classification into medically-relevant syndromes; and (2) aberration detection using time-series focused algorithms, whereby data is synthesized in real-time to detect aberrations as they occur. An aberration is defined as when a time series exceeds a certain value or behaves in a way that is not likely to have occurred by chance alone. ACES employs four families of syndromic surveillance algorithms to detect trends in emergency department visits from across Ontario in real time, which are out of the ordinary and possible public health threats. Aberrations may indicate an outbreak of public health consequence, the beginning of a seasonal trends, or problems with data transfer or submission. The four different families of alert algorithms employed by the ACES system are (1) cumulative sum (CuSum) alerts, (2) Statistical Process Control (SPC) alerts, and (3) an exploratory alert method developed by the National Research Council (NRC). All three families of alerts comprise twelve alert types; using diverse alerts encompasses as wide a range as possible of potential statistical aberrations and ensures that ACES maintains the highest possible sensitivity.

3.4.1 The Cumulative Sum (CuSum) Family of Alerts

The Cumulative Sums (CuSum) family of alerts is based on algorithms developed by the Center for Disease Control's Early Aberration Reporting System (EARS) to detect bioterrorism threats and subsequently implemented by a wide range of health departments across the United States and Canada. EARS was designed to provide enhanced surveillance for a short duration around a discrete event (e.g., Olympic Games, political convention) for which very little background data existed, and therefore alert algorithms use just seven 24 hour periods of data. The set of three EARS algorithms used by ACES are adapted to incorporate a cumulative approach to evaluating the data, and are based on whether daily syndrome (or total) ED counts exceed the expected value by a certain threshold with varying sensitivity. Aberrations in daily counts of ED visits that are above what is expected are assessed according to one-

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sided CuSum calculations. Daily ED counts are described as z_t value that standardize the daily count to the mean and standard deviation for the previous seven days, as follows:

$$z_t = \frac{[x_t - (\mu+\sigma)]}{\sigma} \qquad \text{(Equation 1)}$$

where x_t is the current daily ED count at time t, and μ is the mean and σ is the standard deviation. Consecutive daily ED counts are then compared using the CuSum formula,

$$S_t = \max\left\{0, S_{t\text{-}1} + z_t\right\} \qquad \text{(Equation 2)}$$

where the current CuSum, S_t is the maximum value of zero or the sum of the previous day's CuSum, $S_{t\text{-}1}$, and z_t; if $S_t \geq 3$ an alert is triggered. This threshold is generally accepted as optimal, but a lower value would increase sensitivity. Sensitivity can also be changed by adjusting the time period used to calculate the mean and standard deviation to which daily counts are standardized. CuSum alerts in ACES describe three levels of sensitivity: CuSum1 (mild sensitivity), CuSum2 (medium) and CuSum3 (ultra).

3.4.1.1 CuSum1 - Mild Sensitivity

Consider the following example: the daily counts for ED for visits classified as the syndrome Asthma are shown in Figure 32. These data represent the first two weeks of recorded ED counts, and it is unclear if the ED counts observed on 11-Feb are high in comparison to what may be expected by chance. Using the CuSum alert method described above, a threshold of CuSum ≥ 3 is used. Mean (μ), standard deviation (σ), and CuSum score (z_t) are calculated beginning Feb-04, the first date with seven previous daily ED counts (Table 3). Using equations 1 and 2, z_t and CuSum_t are calculated for subsequent days. Note that CuSum_t values approach zero when hospital visit counts, generally, approach the mean. This method is effectively a measure of a value's proximity to the

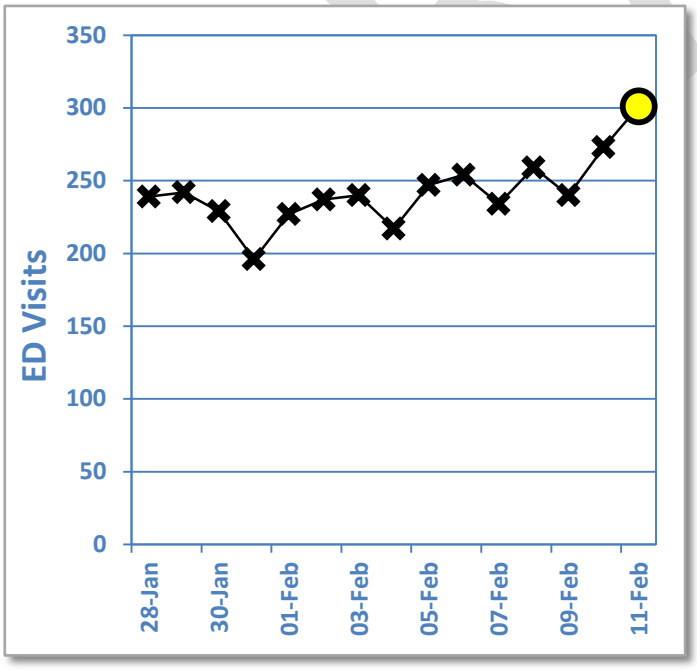

Figure 32. ED visits for Asthma.

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mean. Using this method, the daily emergency department count for Feb-11 would trigger an alert. ACES would notify the administrator of that hospital that the counts for asthma need to be examined in further detail.

Table 3. CuSum1 alert.

DATE	daily counts	μ	σ	z	CuSum1 (t_{-1} to t_{-7})	Alert?
28-Jan	239	232.3				
29-Jan	242	233.3				
30-Jan	229	229.6				
31-Jan	196	227.6				
01-Feb	227	223.6				
02-Feb	237	222.9				
03-Feb	240	225.4				
04-Feb	217	230.0	16.0	-1.81	0	✗
05-Feb	247	226.8	16.1	0.25	0.25	✗
06-Feb	254	227.6	17.0	0.56	0.80	✗
07-Feb	234	231.1	19.7	-0.86	0	✗
08-Feb	259	236.6	12.3	0.82	0.82	✗
09-Feb	240	241.1	14.0	-1.08	0	✗
10-Feb	273	241.6	13.9	1.27	1.27	✗
11-Feb	301	**246.3**	**18.2**	**2.01**	**3.28**	✓

One of the main benefits of CuSum methods for aberration detection is the short period of background data required to calculate alerts. Again, sensitivity to changes in the daily ED counts can be varied according to need and the normal aberrations observed for that data. In the above CuSum (CuSum1) calculations, the mean daily ED visits are determined from the seven days previous to 11-Feb and changes in sensitivity can be achieved by changing the baseline of seven days from t_{-3} to t_{-9} (see Figure 33), as will be discussed for CuSum1 and Cusum2. The benefits of each CuSum approach are discussed in the following sections.

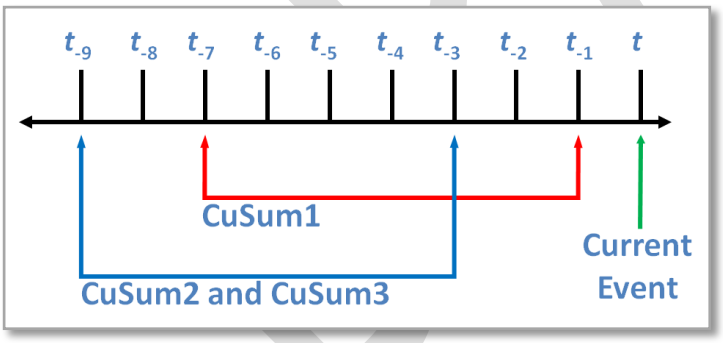

Figure 33. TImeline for CuSum alerts.

The above example describes the calculations involved in a CuSum1 alert, which by definition, is considered an alert of mild sensitivity. The means (μ) and standard deviations (σ) used to calculate CuSum1 are based on daily ED visit counts for the seven days previous to the current day, that is, from t_{-1} to t_{-7} (Figure 33). The threshold limit is defined as three in ACES, and therefore, an alert is flagged when CuSum1 ≥ 3. The sensitivity of CuSum1 can be increased or decreased by changing this threshold. It is important to note that, because the current daily count is compared mean and standard deviation of the previous seven days, if an aberrant value is detected on the current day (t), the CuSum1 calculated for the next day (t_{+1}) will be less likely to surpass the threshold as the previous day's higher-than-average value will increase the values of both the mean and standard deviation.

3.4.1.2 CuSum2 - Moderate Sensitivity

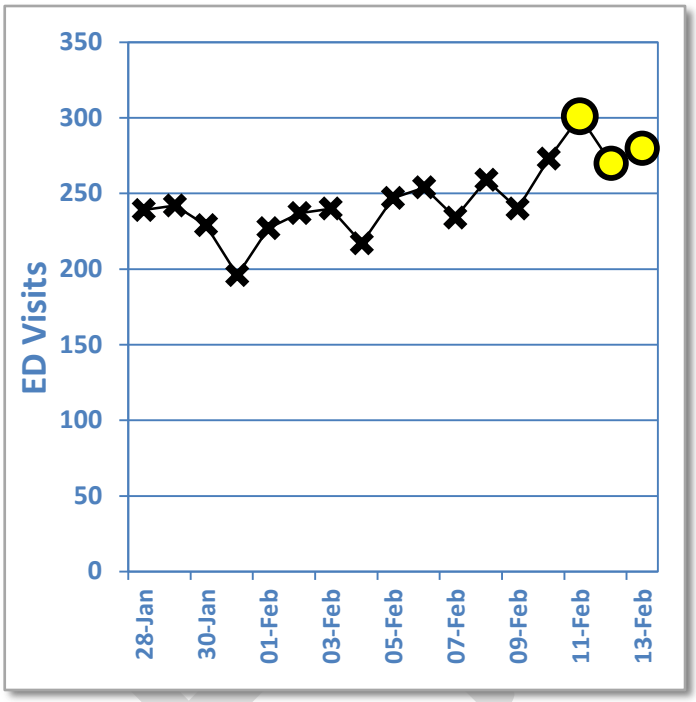

Figure 34. ED visits for Asthma—additional data.

CuSum2 is calculated using the same methods as CuSum1, but with a shifted baseline for calculating the mean (μ) and the standard deviations (σ) (see Figure 33). Changing the timeline for these calculations may increase the sensitivity of this method; the additional two day lag period between the current count and the values used to calculate the mean may increase sensitivity on subsequent days. The same threshold is used as with CuSum1, that is, CuSum2 ≥ 3. The increase in sensitivity is best described visually: the data in Table 3 and Figure 32 is presented again with the addition of two subsequent days of ED counts for the Asthma syndrome (Figure 34, Table 4). You can

Table 4. Comparison of CuSum alerts.

DATE	daily counts	CuSum1 (t_{-1} to t_{-7})					CuSum2 (t_{-3} to t_{-9})					CuSum3	
		μ	σ	z	*Alert?*		μ	σ	z	*Alert?*		*Alert?*	
28-Jan	239	232.3											
29-Jan	242	233.3											
30-Jan	229	229.6											
31-Jan	196	227.6											
01-Feb	227	223.6											
02-Feb	237	222.9											
03-Feb	240	225.4											
04-Feb	217	230.0	16.0	-1.81	0	✗							
05-Feb	247	226.8	16.1	0.25	0.25	✗							
06-Feb	254	227.6	17.0	0.56	0.80	✗	230.0	16.0	0.50	0.50	✗	0.50	✗
07-Feb	234	231.1	19.7	-0.86	0	✗	226.9	16.1	-0.56	0.00	✗	0.50	✗
08-Feb	259	236.6	12.3	0.82	0.82	✗	227.6	17.0	0.85	0.85	✗	1.35	✗
09-Feb	240	241.1	14.0	-1.08	0	✗	231.1	19.7	-0.55	0.30	✗	1.15	✗
10-Feb	273	241.6	13.9	1.27	1.27	✗	236.6	12.3	1.96	2.26	✗	**3.41**	✓
11-Feb	301	**246.3**	**18.2**	**2.01**	**3.28**	✓	**241.1**	**14.0**	**3.28**	**5.55**	✓	**8.11**	✓
12-Feb	270	258.3	22.8	-0.48	2.79	✗	**241.6**	**13.9**	**1.05**	**6.60**	✓	**8.86**	✓
13-Feb	280	261.6	22.5	-0.12	2.61	✗	**246.3**	**18.2**	**0.85**	**7.45**	✓	**7.45**	✓

conceptualize the difference this makes by considering the values used to calculate μ on 12-Feb; for CuSum2, the ED counts from the two days previous to the current value are not included in the calculation. The μ is not, therefore, skewed to a higher number by the anomalously high ED visits observed on 11-Feb. Thus, CuSum1 does not and CuSum2 does generate an alert on 12-Feb; likewise, CuSum2 also generates an alert on 13-Feb.

3.4.1.3 CuSum3 - Ultra Sensitivity

The most sensitive CuSum alert is CuSum3. The calculation of this statistic depends on CuSum2 values: it is the sum of CuSum2 from the current day and the previous two days, but only if the previous two days did not generate alerts. If the previous days' CuSum2 did generate alerts, their values are set to zero, as in the following formula,

$$\text{CuSum3} = \sum S_{t_o} + S_{t_{-1}} + S_{t_{-2}} \qquad \text{(Equation 3)}$$

where S_{t_o} is the CuSum2 value for the current day and $S_{t_{-1}}$ and $S_{t_{-2}}$ are the CuSum2 values for the previous two days. If $S_{t_{-1}} > 3$, then $S_{t_{-1}} = 0$ and if $S_{t_{-2}} > 3$ then $S_{t_{-2}} = 0$ (ACES' alert settings will trigger a CuSum2 alert if CuSum2 > 3). Again, referring to the data shown in Figure 34 and Table 4, the relationship between CuSum alerts can be observed: for this data set, CuSum1 gives one alert on 11-Feb, CuSum2 triggers three alerts on consecutive days (11-Feb to 13-Feb), and CuSum3 has the same results as CuSum2 except that an additional alert is calculated for 10-Feb. The graph (Figure 34) reveals that there appears to be the start of an elevation in ED counts on 10-Feb, and CuSum3 gives a statistical foundation for concern.

3.4.2 Statistical Process Control (SPC)

The Statistical Process Control (SPC) family of alerts were developed and used by the manufacturing industry to improve product quality by reducing product variability. During a manufacturing process, quality control and/or the stability of the process are monitored by measuring a defined parameter; generally, these measurements are amenable to graphical display as a function of time. SPC alerts identify aberrations in measures of quality control or process stability that are unlikely to be caused by chance alone. Measurements of the parameter are compared to their means and standard deviations over defined time periods, and an alert is triggered according to differences in the current measurement from the mean and within defined levels of standard deviation, depending on the type of SPC alert. SPC

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alert methods have been used to monitor and improve hospital performance, and are used in disease surveillance to detect large increases in disease reports for the *National Notifiable Diseases Surveillance System* of the *Centres for Disease Control*.

In ACES, eight different SPC alert types are used: Extreme, Bias, Trend, On Edge, Tendency, Oscillation, Blissful Ignorance, and No Middle Ground. Means and standard deviations are, typically, calculated from the preceding two weeks of ED visit counts, for a particular syndrome. It may be useful to change the sensitivity of an SPC alert by changing the time periods used for calculating means and standard deviations. For every data point measured, three upper control limits (UCL, UCL2 and UCL3) and three lower control limits (LCL, LCL2 and LCL3) are calculated as follows:

$$UCL = \mu + \sigma \quad \text{(Equation 4)}$$

$$UCL2 = \mu + 2\sigma \quad \text{(Equation 5)}$$

$$UCL3 = \mu + 3\sigma \quad \text{(Equation 6)}$$

$$LCL = \mu - \sigma \quad \text{(Equation 7)}$$

$$LCL2 = \mu - 2\sigma \quad \text{(Equation 8)}$$

$$LCL3 = \mu - 3\sigma \quad \text{(Equation 9)}$$

where μ and σ are the mean and is the standard deviation for the previous fourteen days, respectively. SPC alerts in ACES are, generally, associated with only the UCL calculations, as emergency department counts that are above the means are of epidemiological interest in determining possible public health threats.

3.4.2.1 SPC Rule 1 - Extreme

An Extreme alert is the most intuitive of the SPC alerts; it is generated if the current day's emergency department visit count is greater than three standard deviations from the mean (i.e., current count > UCL3). Assuming a normal distribution for the data, the probability that the one data point will be more than three standard deviations than the mean is 0.13%; therefore, a current count beyond three standard deviation of

ADD Example of EXTREME alert as screen shot from ACES

Figure 35. SPC Rule 1 - Extreme.

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the mean has only a 0.13% chance of being due to chance alone. This is epidemiologically relevant as this alert would likely showcase a very sharp incline compared to historic data and require immediate investigation to contain the issue. It would also be useful for hospital administration staff as this type of spike may require more staffing or diversion of patients to other hospital sites depending on the scale of the spike. An example of an Extreme alert is shown in Figure 35**; ADD NOTES FOR SPECIFIC FEATURES.**

3.4.2.2 SPC Rule 2 - Bias

A Bias alert is generated if the current visit count is the ninth in a row where all nine counts are on the same side of the mean; that is, nine daily counts in a row are either greater than the mean or less than the mean. In ACES, an alert will only be triggered if the nine counts are all above the mean. Assuming the data is normally distributed, the probability that a Bias alert will be triggered is 0.4%. An example of a Bias alert is shown in Figure 36. Bias alerts are sensitive to very subtle changes in daily counts as it indicates circumstances where a slight change in counts is observed over several days even when the individual counts may not be dramatic ally higher than the mean (i.e., within one standard deviation). Means and standard deviations for Bias are calculated from the previous fourteen days, so it is also conservative its sensitivity in that the previously higher counts are used in the calculation of the moving average. The chance of nine counts in a row being greater than the mean is very low, and therefore may indicate a true trend of increasing mean emergency department visits. In other words, a trend of increasing visits could signify that there is a health effect of public health consequence in occurrence.

INSERT SCREENSHOT OF BIAS ALERT HERE

Figure 36. SPC Rule 2 - Bias.

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3.4.2.3 SPC Rule 3 - Trend

A Trend alert is a unique SPC alert in that it is not dependent on means or standard deviation calculations. It is triggered in ACES if the current visit count is the sixth in a row where all six counts are increasing. Six counts in a row of decreasing values should also, technically, trigger a Trend alert, but ACES is primarily concerned with monitoring for increasing trends or counts that are anomalously high. The Trend algorithm, therefore, follows these conditions: count t_1 < count t_2 < count t_3 < count t_4 < count t_5 < count t_6. An example of this alert is shown in Figure 37; the highlighted data point is the sixth in a row where all six points are increasing. A Trend alert is epidemiologically relevant as it may reveal an increasing trend in emergency department visit counts before those counts exceed the UCL, such as is described in an Extreme alert. Six points in a row that are steadily increasing is statistically very unlikely, and would represent a rise that is not due to chance alone. This alerts is of epidemiologically relevance, therefore, as it may determine subtle changes in emergency department trends that would not be picked up by other surveillance methods that rely on the current day's values in relation to means and standard deviation.

INSERT TREND ALERT FROM ACES HERE

Figure 37. SPC Rule 3 - Trend.

3.4.2.4 SPC Rule 4 - On Edge

In ACES, an On Edge alert is generated if the current visit count is the second of any two of the last three counts greater than UCL2. The probability of this occurring by chance alone, assuming a normal distribution, is 0.16%. The highlighted data point in Figure 38 is the second point (out of the previous three) that is greater than two standard deviations from the mean. Likewise, Figure 39 is a second example of a circumstance where an On Edge alert would be triggered, but the two points greater than UCL2 are not sequential**. DESCRIBE THE GRAPH, SPECIFIC DATA POINTS, POINT OUT THE RELATIVE SENSITIVITY TO OTHER SPC ALERTS.**

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Insert ACES screenshot of on edge alert, 2 examples, side by side

Figure 38. SPC Rule 4 - On Edge, example 1.

Figure 39. SPC Rule 4 - On Edge, example 2.

3.4.2.5 SPC Rule 5 - Tendency

A Tendency alert is generated if the current visit count is the fourth count in the previous five counts that is greater than). The probability of a Tendency alert being triggered, assuming a normal distribution, is 0.32%. In Figure 40, the highlighted data point would trigger an alert as it is the fourth point of five that falls beyond one standard deviation from the mean, or is greater than the UCL. **DESCRIBE THE GRAPH AND DATA POINTS.**

3.4.2.6 SPC Rule 6 - Oscillation

An Oscillation alert is generated if the current visit count is the 14th in a row where all fourteen counts alternate in direction (sequential increase then decrease). Figure 41 describes a data series that would results in an Oscillation alert. The emergency department visit count on t_{10} triggers alert, since this count is the fourteenth point in a row that alternates direction, or oscillates. This test was introduced with the intent of

INSERT ACES GRAPH OF TENDENCY

Figure 40. SPC Rule 5 - Tendency.

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INSERT GRAPH FROM ACES ALERTS - OSCILLATION

Figure 41. SPC Rule 6 - Oscillation.

describing a process that is likely out of control; fourteen consecutive points that oscillate is statistically very unlikely, and thus the data is not behaving as expected. This alert is, therefore, of little epidemiological concern for disease surveillance as it would not represent any particular kind of outbreak. It is nevertheless of interest for ACES to monitor as it could indicate problems associated with data collection and synthesis.

3.4.2.7 SPC Rule 7 - Blissful Ignorance

A Blissful Ignorance alert is generated when the current day's emergency department visit count is the fifteenth in a row where all fifteen counts are less than the UCL and greater than the LCL. This provides a measure of data quality. Under the assumptions of normal distribution, it is very unlikely that fifteen data points in a row would not exceed one standard deviation difference from the mean; the probability of this occurrence is 0.33%. For the purposes of a manufacturing process, such a pattern may indicate that there is insufficient variation in the data, and the process may out-of-control. For ACES, a Blissful Ignorance alert may not require any specific investigation by epidemiologists, but this test provides a means to monitor data quality. Figure 42 shows an example of Blissful Ignorance, where the highlighted data point is the fifteenth count in a row within one standard deviation, or UCL < count > LCL.

INSERT GRAPH FROM ACES ALERTS - BLISSFUL IGNORANCE

Figure 42. SPC Rule 7 - Blissful Ignorance.

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3.4.2.8 SPC Rule 8 - No Middle Ground

In ACES, a No Middle Ground alert is triggered if the current visit count is the eighth in a row where all eight counts are greater than one standard deviation from the mean. Like Oscillation and Blissful Ignorance, this alert may not be of priority to epidemiologists, but rather identify data with more variation than should occur by chance alone. The probability of the occurrence of this alert, assuming a normal distribution, is 0.01%. Therefore, this indicates that something out of the ordinary is occurring and the process may be out of control. Emergency room visit counts fluctuating beyond one standard deviation is likely of no epidemiological concern. No Middle Ground, therefore, is used to monitor data quality. Figure 43 shows an example of a No Middle Ground alert: the eighth point in a row that is greater than UCL is highlighted. As this alert is used for monitoring data quality, an alert is also triggered when the counts are less than LCL.

INSERT GRAPH FROM ACES ALERTS - NO MIDDLE GROUND

Figure 43. SPC Rule 8 - No Middle Ground.

3.4.3 RecentMax

(NOTE: THIS PREVIOUSLY CALLED NRC) A final alert used by ACES to detect aberrations in daily emergency department visit counts is an experimental method designed by the National Research Council (NRC). RecentMax uses a ten day baseline period to determine a deviation from expected counts. Simply defined, an alert is generated is the current day's count exceeds twice the largest count for the previous ten days, as follows:

$$x_t > \{2 \times \max(x_{t-1} : x_{t-10})\} \qquad \text{(Equation 10)}$$

where x are visit counts for time *t*. This algorithm, although parsimonious, has been shown to perform well at detecting public health threats while simultaneously minimizing the rates of false positives, according to initial research conducted by the NRC. For use in ACES, testing of this algorithm with the multiplicative factor of two resulted in the least sensitivity of all the alerts. Sensitivity has been increased by using the multiplicative factor of 1.5. (ADD EXAMPLE FROM ACES AND DISCUSS,

INSERT GRAPH FROM ACES ALERTS - RecentMax

Figure 44. NRC Algorithm.

Figure 44).

3.4.4 Quick Reference Guide for ACES Alerts

The following chart summarizes the alerts and uses. Please print this out for quick reference.

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Alert *Family*/Name	Baseline no. days	Baseline Period*	Rule (x = daily count)	Probability due to chance	Description	Advantages/Strengths	Disadvantages/ Weaknesses
Cumulative Sum (CuSum):							
CuSum 1 - Mild (C2)	7	t_{-1} to t_{-7}	C1 > 3; when $C1_t = \max(0, C1_{-1} + z_t)$ and $z_t = \frac{[x_t - (\mu+\sigma)]}{\sigma}$		Daily counts are standardized relative to mean values as z scores; C_1 is sum of z for current and previous day's counts.	Requires 7 day baseline to calculate.	Second day of high counts is obscured (x_{-1} included in calculation of μ and σ).
CuSum 2 - Medium (C2)	7	t_{-3} to t_{-9}	C2 > 3; when $C2_t = \max(0, C2_{-1} + z_t)$ and $z_t = \frac{[x_t - (\mu+\sigma)]}{\sigma}$		Daily counts are standardized relative to mean values as z scores; C2 is sum of z for current and previous day's counts. NOTE: C_2 has different baseline than C_1.	Remains sensitive if x_{-1} or x_{-2} triggers alert.	
CuSum 3 - Ultra (C3)	7	t_{-3} to t_{-9}	C3 > 3; when $C3 = C2_t + C2_{-1} + C2_{-3}$ and $C2_x$=0 if > 3		Sum of C2 for current and 2 previous days. $C2_x$ is 0 if it triggered an alert (i.e., greater than 3.		
Statistical Process Control (SPC):							
Extreme	14	t_{-1} to t_{-14}	x_t > UCL3	0.13%	Daily count is greater than 3σ above the μ.		
Bias	14	t_{-1} to t_{-14}	$x_t : x_{-8} > \mu$ OR $x_t : x_{-8} < \mu$	0.13%	9th day of either all above the μ OR all below the μ.		
Trend	NA	NA	$x_{-5} < x_{-4} < x_{-3} < x_{-2} < x_{-1} < x_t$	0.14%	6th day of six days of increasing counts.	Identify trend before x_t exceeds UCL3.	

Alert *Family*/Name	Baseline		Rule (x = daily count)	Probability due to chance	Description	Advantages/Strengths	Disadvantages/ Weaknesses
	no. days	Period*					
On Edge	14	t_{-1} to t_{-14}	x_t > UCL2 for 2 of 3 consecutive counts	0.16%	Any 2 of the last 3 days are greater than 2σ above the μ.		
Tendency	14	t_{-1} to t_{-14}	x_t > UCL for 4 of 5 consecutive counts	0.32%	Any 4 of the last 5 days are greater than σ.		
Oscillation	14†	NA	14 consecutive oscillations	NA	14 counts in a row that alternate direction.	Used as measure of data quality.	Not epidemiologically significant.
Blissful Ignorance	14	t_{-1} to t_{-14}	UCL < x_t:x_{-14} > LCL	0.33%	15th count of 15 that are all less than the UCL and greater than the LCL.	Used as measure of data quality.	Not epidemiologically significant.
No Middle Ground	14	t_{-1} to t_{-14}	x_t:x_{-14} > UCL or < LCL	0.01%	15th count of 15 that are all greater than the UCL or less than the LCL.	Used as measure of data quality.	Not epidemiologically significant.
RecentMax:							
RecentMax	10†	t_{-1} to t_{-10}†	x_t > [1.5 x max(x_{-1}: x_{-10})]		Current count is greater than 1.5 times the maximum value observed in previous 10 days.		

*see Figure 33 for visual description of baseline. †μ and σ are not calculated; number indicates the number of days or the time period for the specific metrics of analysis.

APPENDIX A - ABBREVIATIONS

ACES	Acute Care Enhanced Surveillance
BW	Balanced Winnow (text classifier)
C4.5	C4.5 Decision Tree (text classifier)
CDC	Centre for Disease Control
CoCo	Complaint Coder
CuSum	cumulative sum
DA	dissemination area
EARS	Early Aberration Reporting System
ED	Emergency department
FRI	febrile respiratory illness
FSALDU	Forward sortation area local delivery unit
HIRA	Hazard Identification Risk Assessment
HPPA	Health Protection and Promotion Act
ILI	influenza-like illness
KFL&A	Kingston, Frontenac, Lennox & Addington
LHIN	Local Health Integration Network
ME	maximum entropy
MOHLTC	Ministry of Health and Long-Term Care
MRDx	Most responsible diagnosis
NACRS	National Ambulatory Care Reporting System
NRC	National Research Council
NLP	Natural language processing
PHAC	Public Health Agency of Canada
PHIPA	Personal Health Information Protection Act
PHIMS	Public Health Information Management System
PHU	Public Health Unit
RODS	Real-time Outbreak and Disease Surveillance
SARS	Severe Acute Respiratory Syndrome
SPC	Statistical Process Control
SS	Surveillance system
UCL	Upper control limits

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APPENDIX B - GLOSSARY

alert	An aberration in data that generates an automatic real-time email notification of alert to the syndromic surveillance team. The type of alert is dependent on the algorithm that generates it.
CTAS	The Canadian Triage Acuity Score is a tool that provides a measure of the relative acuity, or severity, and enables EDs to prioritize their patient care requirements, and assess ED workload and resource allocation relative to case mix. Scores are defined as Level 1 (most acute, "Resuscitation"), Level 2 ("Emergent"), Level 3 ("Urgent"), Level 4 ("Semi-Urgent"), and Level 5 ("Non-Urgent").
chief complaint	Chief complaint refers to a short phrase entered by a triage nurse or admissions clerk describing the reason for a patient's visit to an emergency department. CCs are meant to be as short as possible, and therefore will include abbreviations and often idiosyncratic p
CuSum 1, 2 and 3	
EDSS	Emergency Department Syndromic Surveillance. is the original name for the ACES system
epicurve	A graphical display of the number of cases of a particular syndrome over a period of time. ACES uses the distribution of cases to compare normative and aberrant values in order to generate alerts.
FRI screening tool	The FRI screening tool was introduced during the SARS outbreak in 2003. Patients presenting to participating hospitals were screened for respiratory illness using a standard series of questions to identify new or worsening cough, shortness of breath, fever, shakes or chills in the last 24 hours.
forward sortation area local delivery unit (FSALDU)	The first three characters of a Canadian postal code are the forward sortation area (FSA) and the last three characters are the local delivery unit (LDU). The first character generally refers to the province or territory, and geographical information becomes more focussed with each character. The postal code is specific to a unique geographical unit with, on average 400 to 700 residents.
ILI Mapper	Influenza-Like-Illness Activity Level Indicator. This is a feature of the map function where when the user selects ILI as their syndrome, a colour classification system layers over the map in the areas of the region experiencing Influenza, based on number of cases detected for the hospitals in that region.
RODS	Stands for Real-time outbreak and disease surveillance, the biosurveillance system employed in by its creators at the University of Pittsburgh for the 2002 Salt Lake City Olympics. For a full history of RODS as well as its current applications please view the RODS Laboratory website at www.rods.pitt.edu.
syndrome	A grouping of symptoms to represent a single disease (e.g., asthma, COPD), similar diseases (e.g., gastroenteritis, sepsis), or particular kind of adverse health outcome (e.g., toxicology, environmental). Syndromes can be adjusted based on the purpose of monitoring. For full list of ACES syndromes see table APPENDIX C - ACES Syndromes.

APPENDIX C - ACES SYNDROMES

ACES Code	Syndrome Description
ALLERG	allergic reaction, angioedema (not bee sting)
AST	asthma, wheeze, difficulty breathing, SOB
BITE	human, animal, bug (not tick related)
BRONCH	bronchiolitis, RSV
BURN	burns –chemical and thermal, electrical shock
CAD	coronary artery disease, chest pain
CARD	pericarditis, effusion, myocarditis, endocarditis
CDIFF	c difficile
CELL	cellulitis, non wound infection, non abscess
CHF	congestive heart failure
CO	carbon monoxide exposure or other gases—sulphur etc——
CONC	concussion, head injury,
COPD	chronic obstructive lung disease,
CROUP	croup-PIV
CV	cardiovascular (excludes MI and strokes; includes peripheral vascular disease)
DEHY	dehydration
DENT	dental pain, infection, trauma to tooth etc
DERM	rash, undifferentiated, lesion, wart
DM	diabetes and its complications
ELECT	electrolyte imbalance, hyperkalemia, hypomagnesium, hyponatremia
ENT	related to ears nose throat-surgery, non infectious, tinnitus (not in GNSURG)
ENVIRO	heat stroke, heat syncope, heat exhaustion, cold-frost bite, hypothermia
EOH	alcohol and complications-intoxication, addiction, withdrawal or end organ damage
FALL	falls undifferentiated
FBI	foreign body ingestion-nose to anus
FEB	febrile neutropenia
GASTRO	gastroenteritis
GB	Guillain Barre syndrome, flaccid paralysis
GI	GI bleed-upper and lower, epistaxis, hemoptysis
GMED	general medical admission-other-unconscious weakness, unwell, chronic diseases
GNSURG	general surgical admission-appendicitis, cholecystitis, bowel obstruction
GYN	gynecological, bleed, hysterectomy, PID
HEAD	undifferentiated headache, non traumatic
HEM	hematological condition, anemia, thrombocytopenia, not oncological
HEP	hepatitis, undifferentiated and A,B,C
ILI	fever, myalgia, undifferentiated flu
INF	non specific infections-potential interest to public health, epiglotitis, tonsil abscess
INJ	sprain, strain, laceration, dislocation, bruise, swelling
INS	insomnia, sleep disorder
INT	intussecption

ACES Code	Syndrome Description
LAC	lacerations
MEDREN	medication renewal, request
MEDSE	medication side effect-not OD
MEN	meningitis and encephalitis
MH	mental health
MHS	suicidal ideation, attempt or overdose
MIGR	migraine
NEC	necrotizing fasciitis, severe cellulitis, gangrene
NEURO	dementia, Alzheimer's, stroke, seizure, vertigo, syncope, fainting
NEUS	neurosurgery-aneurysm, bleed etc, subdural , SAH
NEWB	newborn
OBS	related to obstetrics
ONC	oncology
OPI	opioid intoxication, addiction overdose, withdrawal
OPTH	general ophthalmological condition
ORTHF	fracture, non hip
ORTHH	fracture of the femur or hip
ORTHO	orthopedic elective surgery, cast change or assessment
OTHER	null, missing, other
PAIN	pain, undifferentiated, non cancer, radiculopathy, back pain, sciatica
PE	pulmonary embolism, DHT, VTE
PHYSC	physician consultation
PN	pneumonia
PO	post op infection or complication
REN	renal failure, dialysis, renal disease and its complications
REPORT	reportable diseases
RESP	respiratory infection non croup, non bronchiolitis
SEP	bacteremia, SEPSIS
SI	smoke inhalation, chemical, gases
SOC	social admission
TEST	test results, blood or diagnostic imaging, xray, US, biopsy,transfusion, tube change
THOR	thoracic, pneumothorax
TICKS	ticks
TOX	toxicology-not alcohol or opioids, withdrawal, substance abuse, chemical exposure
TRMVC	trauma from a MVC/ATV
TRO	trauma from another means, fall etc.
TRW	gunshot or stab, violence, assault
TRS	sexual assault, rape
URO	urological -stones, prostate, UTI
VOM	vomiting-alone-NORO like illness, not secondary to chemo or with other symptoms

APPENDIX D - HPPA REPORTABLE DISEASES IN ONTARIO

Acquired Immunodeficiency syndrome (AIDS)
Acute Flaccid Paralysis
Amebiasis
Anthrax
Botulism
Brucellosis
Campylobacter enteritis
Chancroid
Chickenpox
Chlamydia trachomatis infections
Cholera
***Clostridium difficile* associate disease (CDAD) outbreaks in public hospitals**
Creutzfeldt-Jakob Disease, all types
Cryptosporidiosis
Cyclosporiasis
Diphtheria
Encephalitis including (1) Primary, viral, (2)Post-infectious (3) vaccine-related, (4) subacute sclerosing panencephalitis, (5) unspecified
Food poisoning, all causes
Gastroenteritis, institutional outbreaks
Giardiasis, except asymptomatic cases
Gonorrhoea
Group A Streptococcal disease, invasive
Group B Streptococcal disease, neonatal
Haemophilic influenza b disease, invasive
Hantavirus Pulmonary Syndrome
Hemorrhagic fever, including (1) Ebola virus disease, (2) Marburg virus disease, (3) Other viral causes
Hepatitis, viral (1) hepatitis A (2) hepatitis B, (3) hepatitis C
Influenza
Lassa Fever
Legionellosis
Leprosy
Listeriosis
Lyme Disease
Malaria
Measles
Meningitis, acute (1) bacterial, (2) viral, (3) other
Meningococcal disease, invasive
Mumps
Opthalmia neonatorum
Paralytic Shellfish Poisoning
Paratyphoid Fever
Pertussis
Plague
Pneumococcal disease, invasive
Poliomyelitis, acute
Psittacosis/Ornithosis
Q Fever
Rabies
Respiratory infection outbreaks in institutions
Rubella
Rubella, congenital syndrome
Salmonellosis
Severe Acute Respiratory Syndrome (SARS)
Shigellosis
Smallpox
Syphilis
Tetanus
Trichinosis
Tuberculosis
Tularaemia
Typhoid Fever
Vertoxin-producing E. Coli infection, including Haemolytic Uraemic Syndrome (HUS)
West Nile Virus including (1) West Nile Fever, (2) West Nile neurological manifestations
Yellow Fever
Yersiniosis

***Bolded items** (and Influenza in institutions) should be reported immediately to the Medical Officer of Health by telephone. Other diseases can be reported by the next working day by fax, phone or mail.

APPENDIX E - ACES PARTICIPATING HOSPITALS

Health Unit (Key Below)	Hospitals within Health Unit	ACES start
APH	Blind River District Health Centre (BRH)	Feb-2013
	Lady Dunn Health Centre (WAW)	Jul-2011
	Sault Area Hospital (SAH)	Sept-2014
	St. Joseph's General Hospital (QEL)	Jul-2011
CKPHU	Chatham-Kent Health Alliance – Chatham (CKHA)	Jun-2013
	Chatham-Kent Health Alliance – Wallaceburg (CKHAW)	Jun-2013
DRHD	Lakeridge Health – Bowmanville (LHB)	Sep-2013
	Lakeridge Health – Oshawa (LHO)	Sep-2013
	Lakeridge Health – Port Perry (LHP)	Sep-2013
	Rouge Valley Health System – Ajax and Pickering (APG)	Sep-2013
EOHU	Cornwall Community Hospital	TBD
	Glengarry Memorial Hospital (HGMH)	Apr-2010
	Hawkesbury and District General Hospital	TBD
	Winchester District Memorial Hospital	TBD
GBHU	Grey Bruce Health Services – Lion's Head (LHSH)	Nov-2011
	Grey Bruce Health Services – Markdale (MDSH)	Nov-2011
	Grey Bruce Health Services – Meaford (MFSH)	Nov-2011
	Grey Bruce Health Services – Owen Sound (OSSH)	Nov-2011
	Grey Bruce Health Services – Southampton (SSH)	Nov-2011
	Grey Bruce Health Services – Tobermory (TSH)	Nov-2011
	Grey Bruce Health Services – Wiarton (WSH)	Nov-2011
	Hanover and District Hospital (HADH)	Nov-2011
	South Bruce Grey Health Centre – Chesley (CSH)	Nov-2011
	South Bruce Grey Health Centre – Durham (DSH)	Nov-2011
	South Bruce Grey Health Centre – Kincardine (KSH)	Nov-2011
	South Bruce Grey Health Centre – Walkerton (SWH)	Nov-2011
HKPRDHU	Campbellford Memorial Hospital	TBD
	Haliburton Highlands Health Services	TBD
	Northumberland Hills Hospital	TBD
	Ross Memorial Hospital	TBD
HRHD	Halton Healthcare Services – Georgetown (GEO)	Oct-2011
	Halton Healthcare Services – Milton (MIL)	Oct-2011
	Halton Healthcare Services – Oakville (OAK)	Oct-2011
	Joseph Brant Memorial Hospital (JBMH)	Oct-2011
HPH	Hamilton Health Sciences Corporation – Hamilton General Hospital and Urgent Care Centre (HAH)	Sep-2011
	Hamilton Health Sciences Corporation – Juravinski Hospital and Cancer Centre (HEN)	Sep-2011
	Hamilton Health Sciences Corporation – McMaster Children's Hospital (MCM)	Sep-2011
	St. Joseph's Healthcare Hamilton (ST01)	Sep-2011
HPECHU	Quinte Healthcare Corporation – Belleville (BGH)	Sep-2005
	Quinte Healthcare Corporation – North Hastings (NHH)	Sep-2005
	Quinte Healthcare Corporation – Prince Edward County (PEC)	Sep-2005
	Quinte Healthcare Corporation – Trenton (TMH)	Sep-2005
KFLA	Hotel Dieu Hospital (HDH)	Sep-2005
	Kingston General Hospital (KGH)	Sep-2005
	Lennox & Addington County General Hospital (LACGH)	Sep-2005
LAMBTON – CHSD	Bluewater Health - Sarnia (BWH)	Jun-2013
	Charlotte Eleanor Englehart Hospital of Bluewater Health –Petrolia (BWHP)	Jun-2013
LGLDHU	Brockville General Hospital (BRGH)	Jul-2009
	Carleton Place and District Memorial Hospital (CCC)	Oct-2014

Health Unit (Key Below)	Hospitals within Health Unit	ACES start
	Perth & Smiths Falls District Hospital – Great War Memorial Site – Perth (GWMH)	Nov-2008
	Perth & Smiths Falls District Hospital - Smiths Falls Site (SFH)	Jul-2008
NRPH	Niagara Health System – Douglas Memorial Hospital Site (DMH)	Feb-2010
	Niagara Health System – Greater Niagara General Site (GNG)	Feb-2010
	Niagara Health System – Port Colborne General Site (PCG)	Feb-2010
	Niagara Health System – St. Catharine's General Site (SCG)	Feb-2010
	Niagara Health System – Welland Hospital Site (WHS)	Feb-2010
NBPH	West Nipissing General Hospital (WNGH & WNG)	Apr-2010
	North Bay General Hospital (NBGH)	Apr-2010
	Mattawa General Hospital (MH & MGH)	Apr-2010
NWHU	Atikokan General Hospital (ATGH)	Sep-2010
	Lake-Of-The-Woods District Hospital (LWDH)	Aug-2010
	Riverside Health Care Facilities Inc. (RHF)	Sep-2010
	Sioux Lookout Meno Ya Win Health Centre (SLH)	Sep-2010
OPH	Queensway Carleton Hospital (QOQ)	Oct-2014
PEEL	Trillium Health Partners - Credit Valley Hospital (CVH)	Nov-2011
	Trillium Health Partners - Mississauga Hospital (MISS)	Feb-2013
	William Osler Health System - Brampton Civic Hospital (BCH)	Jan-2011
PCCHU	Peterborough Regional Health Centre (PRH)	Apr-2009
PHU	MICs Group of Health Services – Anson General Hospital (AGH)	Jul-2011
	MICs Group of Health Services – Bingham Memorial Hospital (BMH)	Jul-2011
	MICs Group of Health Services – Lady Minto Hospital (LMH)	Jul-2011
	Hôpital de Smooth Rock Falls Hospital (FSR)	Jul-2011
	Hôpital Notre-Dame Hospital (NDH)	Feb-2013
	Hornepayne Community Hospital (HPH)	Feb-2013
	Sensenbrenner Hospital (SBH)	Feb-2013
	Timmins & District General Hospital (TDH)	Jul-2011
SMDHU	Georgian Bay General Hospital - Midland Site (GBGH)	Feb-2010
	Muskoka Algonquin Healthcare – Huntsville & Bracebridge (MAH)	Feb-2010
	North Simcoe Hospital Alliance – Huronia District Hospital	TBD
	Orillia Soldiers' Memorial Hospital (OSMH)	Feb-2010
	Royal Victoria Hospital (RVH)	May-2010
	Stevenson Memorial Hospital	TBD
SDHU	Chapleau General Hospital (CHS)	Jul-2011
	Espanola Regional Hospital and Health Centre (EGH)	Feb-2013
	Manitoulin Health Centre (MHC)	Feb-2013
	Sudbury Regional Hospital (SRH)	Feb-2011
TBDHU	Dryden Regional Health Centre (DRH)	Sep-2010
	Geraldton District Hospital (GDHO)	Sep-2010
	Manitouwadge General Hospital (MGHO)	Sep-2010
	McCausland Hospital (MCCA)	Sep-2010
	Nipigon District Memorial Hospital (NDMH)	Sep-2010
	Thunder Bay Regional Hlth Sciences Centre (TBRH)	May-2010
	Wilson Memorial General Hospital (WMGH)	Sep-2010
THU	Englehart And District Hospital (EDH)	Jul-2011
	Kirkland And District Hospital (KDH)	Jul-2011
	Temiskaming Hospital (TEM)	Jul-2011
TPH	The Hospital for Sick Children	TBD
	Mount Sinai Hospital (MSH)	Oct-2013
	North York General Hospital	TBD
	Rouge Valley Health System – Centenary (RVC)	Sept-2013
	The Scarborough Hospital – General Site (TSH)	Jan-2014
	The Scarborough Hospital – Birchmount Site (TSHB)	Jan-2014

Health Unit (Key Below)	Hospitals within Health Unit	ACES start
	St. Joseph's Health Centre (STJOE)	Jun-2010
	St. Michael's Hospital (SMH)	Mar-2013
	Sunnybrook Health Sciences Centre	TBD
	Toronto East General Hospital	Oct-2014
	University Health Network – General Site (TGH)	July-2013
	University Health Network – Princess Margaret (PMH)	July-2013
	University Health Network – Western Site (TWH)	July-2013
	William Osler Health System - Etobicoke General Hospital (EHC)	Jan-2011
WECHU	Hôtel-Dieu Grace Hospital (HDGH)	Jun-2013
	Leamington District Memorial Hospital (LDMH)	Jun-2013
	Windsor Regional Hospital (WRH)	Jun-2013

Health Unit Abbreviations:

APH: Algoma Public Health

CKPHU: Chatham-Kent Public Health Unit

DRHD: Durham Region Health Department

EOHU: Eastern Ontario Health Unit

GBHU: Grey Bruce Health Unit

HKPRDHU: Haliburton, Kawartha, Pine Ridge District Health Unit

HRHD: Halton Region Health Department

HPH: Hamilton Public Health

HPECHU: Hastings and Prince Edward County Health Unit

KFLA: KFL&A Public Health

LAMBTON - CHSD: Lambton - Community Health Services Dept.

LGLDHU: Leeds, Grenville and Lanark District Health Unit

NRPH: Niagara Region Public Health

NBPH: North Bay Public Health

NWHU: Northwestern Health Unit

OPH: Ottawa Public Health

PEEL: Peel Public Health

PCCHU: Peterborough County City Health Unit

PHU: Porcupine Health Unit

SMDHU: Simcoe Muskoka District Health Unit

SDHU: Sudbury & District Health Unit

TBDHU: Thunder Bay District Health Unit

THU: Timiskaming Health Unit

TPH: Toronto Public Health

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